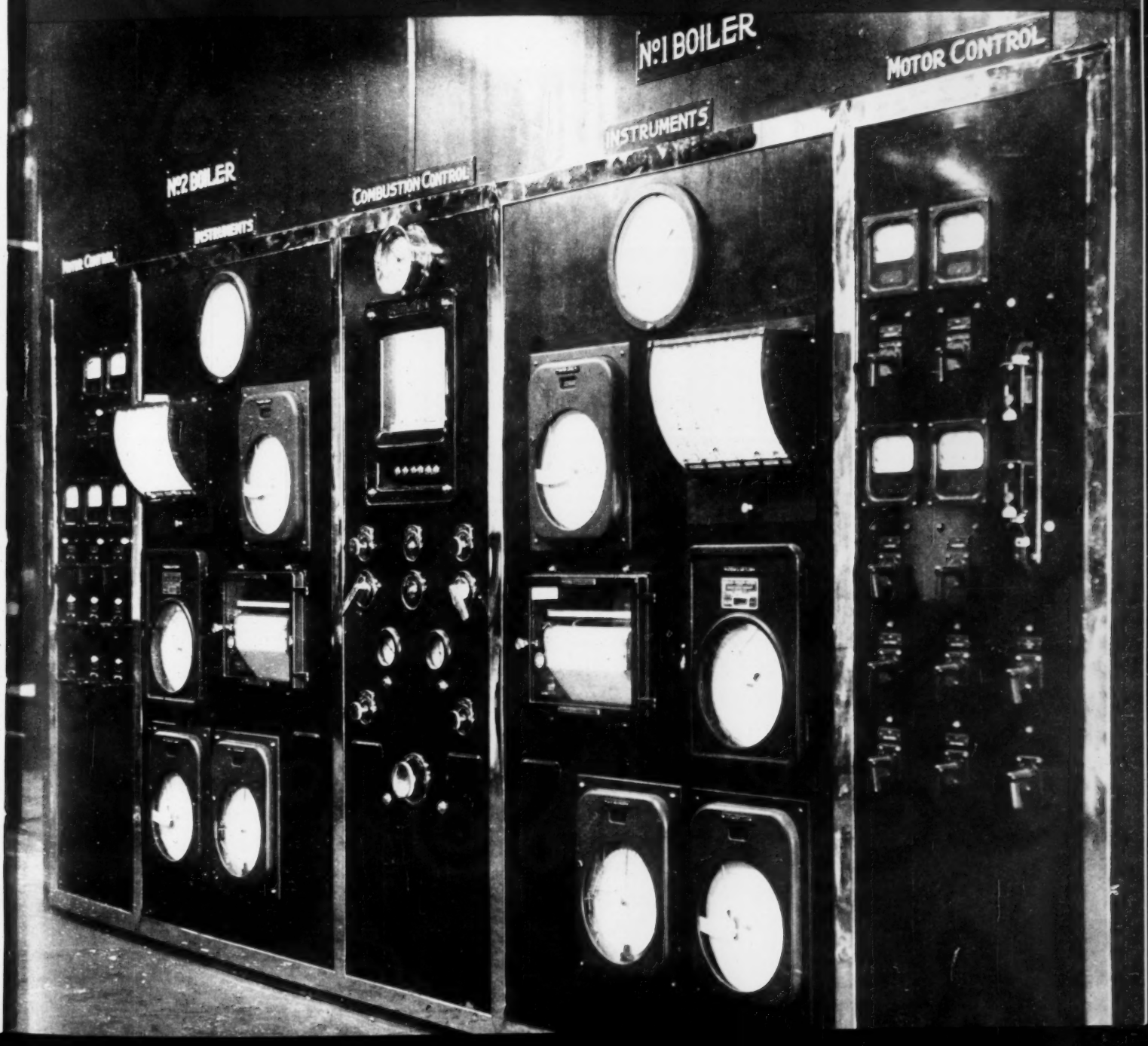
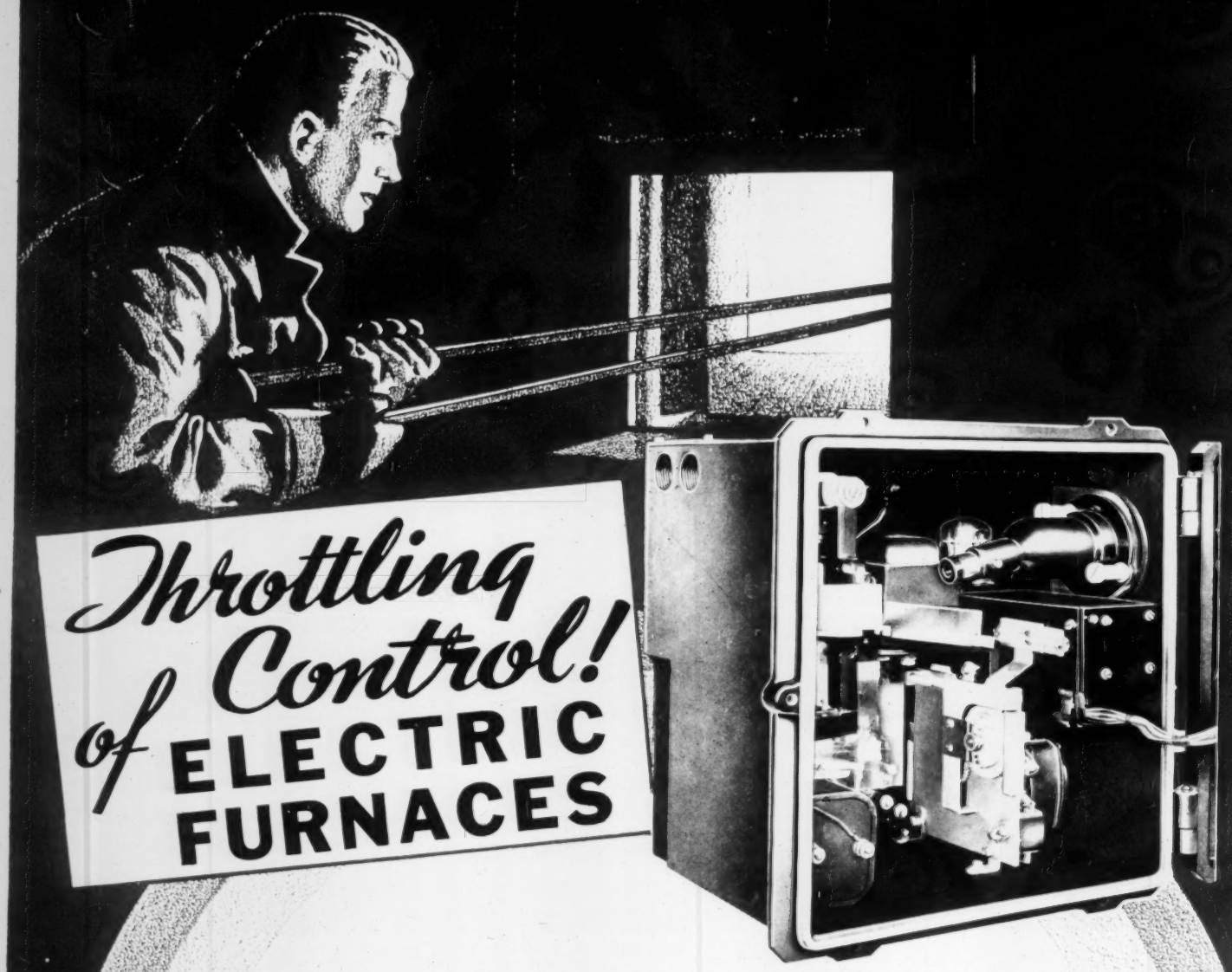
Instruments

THE MAGAZINE OF Measurement and Control

Vol. 11
FEB.
1938
No. 2





Throttling Control! of ELECTRIC FURNACES

THROTTLE ELECTRIC HEAT

Economical means are now available for controlling electric furnaces in the same manner as fuel-fired furnaces are sometimes controlled. . . The remarkable, new TAG CELECTRAY Indicating Controller provides it with no other equipment than is ordinarily used for on-and-off control. This Controller employs the CELECTRAY principle of photoelectric detection of the position of a light-beam reflected from a mirror galvanometer toward a reciprocating controlling edge. It has no dead zone and holds a steady temperature without oscillation. The throttling zone can be readily adjusted within wide limits, and load error kept within a few degrees without introducing appreciable hunting. Adjustment for load error is provided.

Ask for complete details and learn what this new development and other CELECTRAY Indicating, Recording and Controlling PYROMETERS can do for your process in terms of product improvement. A new TAG Catalog No. 1101-I effectively describes and illustrates CELECTRAY PYROMETERS in service. Write for your copy today.

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

TAG TAGLIABUE BROOKLYN N.Y. U.S.A.

King Canute GOT HIS FEET WET...

AND YOU endanger your products without accurate regulation of liquid level ... Ask Taylor Engineers how to do it most efficiently in your plant.

IT IS REPORTED that King Canute tried to control liquid level by command. But he got his feet wet. Industries for years did it manually—and often experienced trouble with product uniformity and quality. Today Taylor does it for many plants—automatically, precisely, economically.

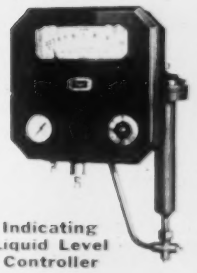
Whatever the liquid level requirements in your plant, there is a Taylor System of Control to meet them. Taylor Systems cover all control ranges. The line includes differential pressure, static pressure and float-type controllers. The famous Taylor Fulscope is used with all three types; the same quality of control is obtainable with all. The "Universal Sensitivity Adjuster," an exclusive Taylor feature, permits you to fit a Taylor Liquid Level Controller into the operating characteristics of any process and cope with any changing conditions.

Let Taylor Engineers survey your plant and help you decide where Taylor Liquid Level Control will mean even more efficient operation. For this service and for the new 60-page Catalog 70J, which describes Taylor Liquid Level and Flow Instruments, see a Taylor representative, or write Taylor Instrument Companies, Rochester, N.Y. Plant also in Toronto, Canada. Manufacturers in Great Britain—Short & Mason, Ltd., London, Eng.

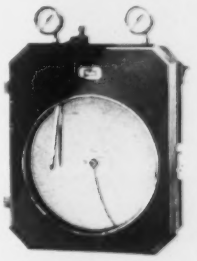
Taylor

Indicating Recording · Controlling

TEMPERATURE, PRESSURE, FLOW *and* **LEVEL INSTRUMENTS**



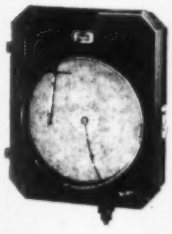
Indicating Liquid Level Controller



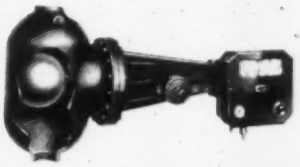
Recording Liquid Level Controller

. . .

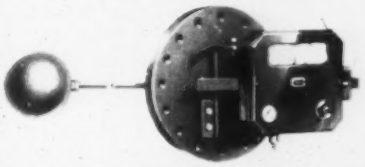
Time Schedule, Liquid Level Controller



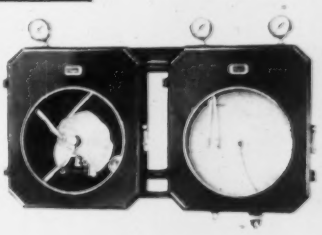
Liquid Level Recorder



External-float Type Liquid Level Controller



Internal-float Type Liquid Level Controller



THE MAINTAINED in-built accuracy of Westcott orifice meters, whether for Indicating, Recording or Integrating, is embodied in: precision machining of differential gage body chambers . . . low angle of float travel . . . small angular travel of static pressure tube . . . only one movable part between mercury surface and chart record. • Information is available on request.

AMERICAN METER COMPANY
METRIC METAL WORKS ERIE, PENNSYLVANIA

"USING CHACE Thermostatic BIMETAL

Pittsburg's Automatic Gas Storage Water Heater MODEL M-1"

THE PITTSBURG WATER HEATER CORP.
PITTSBURGH PA.

THIS Pittsburg heater keeps water at desired temperature by thermostatic control. It is also equipped with automatic safety pilot light control. Chace Thermostatic Bimetal is the actuating element used to produce the necessary action.

If your product demands action at pre-determined temperature perhaps "Chace" is the answer. May we co-operate with you?

W. M. CHACE CO.
1609 Beard Avenue - - - Detroit Mich.

Instruments
THE MAGAZINE OF MEASUREMENT and CONTROL

VOL. 11 No. 2

FEBRUARY, 1938

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NOTICE. INDEX TO VOL. 10 (1937)
In the next issue (March) there will be inserted the Index to Vol. 10, ready for binding.

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RICHARD RIMBACH, Managing Editor
M. F. BEHAR, Editor

BRANCH OFFICES

Boston: James Condon, 6 Marlboro St. (Kenmore 2354)
New York: R. K. Farnham, 118 E. 28th St. (Lexington 2-4637)
Chicago: William Farnham, 201 N. Wells St. (Andover 4180)
Cincinnati: E. Eggers, 2316 Kenilworth Ave. (Jefferson 4722)
Philadelphia: R. K. Farnham, 1533 Cherry St. (Rittenhouse 2530)

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

A few hours after last month's big special issue came off the press, an old friend dropped in: an instrumengineer who has never uttered a compliment since he courted his fiancée. He scanned Part One silently—once, twice, a third time; then, his index bearing down on the Contents page and his steely eyes boring ours: "No 'New Instruments' Department. It's like *Time* Magazine without 'National Affairs'!"

Our reply: "Next month I'll put in *nothing but* regular features. How will you like *that?*"

Joking aside, our main purpose is to give you time to assimilate all the meaty articles we were privileged to run last month.

By the way, the "New Instruments" Department is now made up so that items are not printed back-to-back. Several readers suggested it and always obedient . . .

THE FRONT COVER

Another handsome high-pressure-boiler control board: the one just installed at the RCA Mfg. Co., Camden, N. J. Principal instruments are Cochrane boiler drum level and feed water meters, Hays CO_2 recorders and draft gages, Bailey flowmeters, Brown potentiometers and Smoot combustion controls. The two 120,000-lbs./hr. boilers generate steam at 900 lbs. gage and 225° superheat.

Robert F. Farnham

Robert F. Farnham, Chicago representative of The Instruments Publishing Co., died of a stroke on the morning of February 1st. Born in Fergus Falls, Minn. in 1884, Mr. Farnham was for many years associated with industrial publications. He had been representing *Instruments* and *The Instrument Maker* since 1934. William Farnham, his son, will take over the western territory.

Instrumentation's Unity

FIRST of all, a reminder that the January issue as mailed to every subscriber consisted of two parts, bound separately. (Part One containing fourteen "Decade of Progress" articles; Part Two, *The 1938 Instruments Index.*) Did both reach you? If not, don't blame our circulation department until after you've investigated, especially if you receive your *Instruments* in a plant where others—whether on the route slip or not—find this magazine useful.

It is too early to form an exact picture of your complete reaction to this Tenth Anniversary Issue. This was the first special issue of *Instruments* and although both the publisher and the editor worked 60 to 80 hours a week for two months, it was not completely printed until January 31. The few dozen comments received to date are all brief congratulations from which we can only draw the broad outline of the picture; to fill in details will require examining scores of comments—all made after careful reading of the review-and-forecast articles in Part One.

Read them all! You already have studied one or two with care and skimmed through four or five others—these five or seven immediately applicable to your work. Well and good, but you will find useful ideas in the others—those with titles that do not suggest direct connection with your particular responsibilities.

Not only will you find useful ideas but you will become more saturated with the single fundamental idea. In every activity there is a sort of "golden key" to success. In golf and other sports, for instance, it is "keep your eye on the ball." In Instrumentation it is the application of its fundamental doctrines:

(1) Eliminate the *variables* by reducing them to *measurables*;
(2) Whatever is to be controlled should first be measured;
(3) If you can measure it you can control its effects.
(4) If you can control by hand you should control automatically.

The few brief comments already received indicate an awareness of this keynote running through the "Decade of Progress" articles. The authors all held to this keynote because, though engaged in various industries, they all are Instrumenticians. They all come from the ranks of instrument *users*. In short, they represent *you!* At times in the past we ventured to remark that our readers constitute a sort of fraternity, or profession. This has become an obvious fact. Some ten thousand useful citizens are bound together by interest in Measurement and Control.

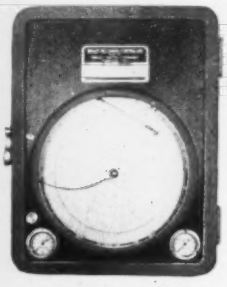
BAILEY METER CONTROL SYSTEM

The Mark of

Effective Control

Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

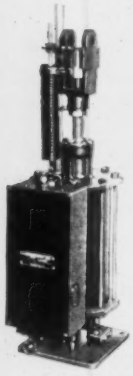
Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.



Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY

1041 Ivanhoe Rd., Cleveland, Ohio

NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

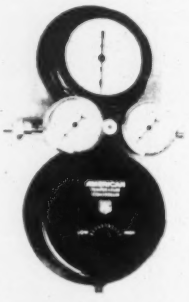
Thermionic Amplifier

Bringing high sensitivity to potential measurements in high resistance circuits, this thermionic amplifier, drawing a negligible current, adapts any potentiometer

of suitable range to the measurement of potentials encountered in glass electrode work, polarization studies, corrosion, oxidation-reduction, etc. Resistors of high values can be measured at voltages at which they are used. It requires little manipulation other than preliminary adjustments. Readings are rapidly obtained by the routine potentiometer measurement. The control current may be adjusted to be less than 10^{-14} amp. at balance, and when so adjusted the error caused by this current is 1.0 millivolt in a 100,000 megohm circuit. For circuits of lower resistance this error is proportionately less. *Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Pa.*

Wide-range Indicating Air-operated Controller

Supplements "Wide-range" line of small *non*-indicating air-operated temperature and pressure controllers (see *Instruments*, March 1937, page 62). Each instrument consists of one of these "Wide-range," controllers together with a dial thermometer or a pressure gage, on a drilled, ready-for-mounting, 6" × 12" aluminum plate (dimly visible in our illustration). Scale graduations on indicator correspond to working range of the automatic controller. Controller specifications are as printed in our March 1937 issue.—*Consolidated Ashcroft Hancock Co., Inc., Bridgeport, Conn.*



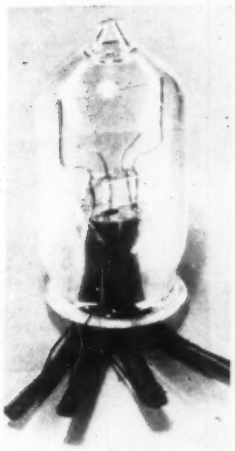
Stainless Steel Laboratory Thermometer

New type of laboratory thermometer, comprising dial indicator and 8" stainless steel stem, is said to be the first dial-type thermometer with an all-metal temperature element sufficiently accurate for scientific use. Thermal element is an internally-balanced bi-metallic double coil (see *Instruments*, Nov. 1935, page 305) sealed in terminal 1½" of seamless stem. When stem is immersed to a depth of 1½" in a liquid (3" in gas or vapor), temperature is indicated without necessity for stem correction. Accuracy guaranteed 0.5% over entire scale. Location of dial away from fluids under measurement minimizes errors of observation; dial markings are not subjected to obliteration from the solutions under test or to obscuration in dark-colored or viscous solutions. Stem is ¼" seamless tubing of "18-8" chromium-nickel alloy steel, corrosion-proof to all but a few laboratory reagents. Bi-metallic coil is shock-proof. "Reasonable overrange temperatures" do not impair accuracy. Initial models are offered in following scale ranges: 0-220° F., 50-300° F., 50-500° F., 0-100° C., 0-150° C.—*Weston Electrical Instrument Corp., 581 Frelinghuysen Ave., Newark, N. J.*

Small Phototube

Latest addition to Visitron line of phototubes is Type 62A, said to have all the performance characteristics of larger G-M phototubes. Overall height (not incl. prongs) 2"; bulb diam. ⅞"; sensitive plate height ¾"; plate width ⅝"; distance from bottom of base to center of sensitive plate 1½".—*G-M Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.*

Vacuum . . . Thermocouples



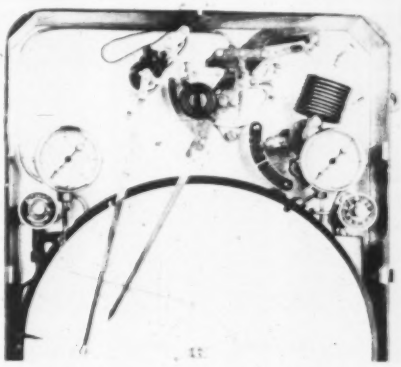
Ranges from 1 milliampere to 10 amperes, in either contact or separate heater types. Prices from $3.00, quantity discounts.

Write for Bulletin "A"

AMERICAN Electrical Sales Co. Inc.
67 E. 8th St. New York, N. Y.

Controllers with Automatic Reset

"Free-Vane" automatic control instruments for temperature, flow, pressure, etc., (*see Instruments*, Jan., 1932, page 9; August 1936, page 213; Sept. 1936, page 248) are now available in new models



with wide throttling range and automatic reset features. The additional device which provides these modes of control lends itself to ready adjustment by user. With these new "Reset Free-Vane Controllers," any load change, accompanied by a movement of the pen away from the control point, produces a change in the controlled air pressure, of sufficient value to give the diaphragm valve the required opening to bring the variable back to the control point. The design of the reset operating mechanism makes it possible to obtain this change automatically, at a rate that corresponds to that required by the particular process being controlled. *The Bristol Co., Waterbury, Conn.*

S-M-O-O-T-H VOLTAGE CONTROL for A.C. circuits

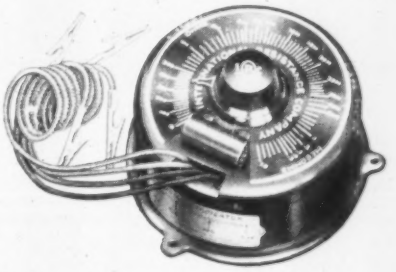
The Type "TH" Transtat is the new continuously variable auto-transformer regulator . . . the ideal voltage control for a.c. circuits. It offers high efficiency, good regulation, great flexibility and dependable construction at moderate cost. Standard types are available for controlling voltage to single-phase and polyphase loads rated 10 Kva. and smaller, 50 or 60 cycles, 115, 230 or 460 volts. May we send you bulletin 51-1 which contains complete data?

TRANSTAT
VOLTAGE REGULATORS

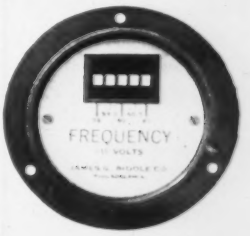
AMERICAN TRANSFORMER CO.
178 Emmet St. Newark, N. J.

Variable Resistor

Continuously variable in a range from 0 to 1.0 megohm with a direct reading calibrated dial, new "IRC" Resistance Analyzer and Indicator" is both a wire-wound rheostat or potentiometer (0 to 30,000 ohms) and a carbon rheostat or



potentiometer (0 to 1 megohm). Electrically, it consists of two sections: a heavy-duty wire-wound rheostat (0-30,000 ohms) and a specially designed Metallized type resistor (30,000 ohms to 1 megohm) similar to those in maker's Metallized type Volume Controls. New device comes with four test leads having small-size alligator clips; three different fuses required for different applications, and an instruction manual covering numerous applications. Case is of Bakelite, 5" diam. and 3" high. *International Resistance Co., 401 N. Broad St., Philadelphia, Pa.*

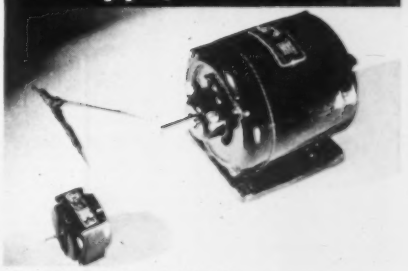


A DEPENDABLE *MINIATURE* FREQUENCY METER

Just as accurate and reliable as our large, wide-range Frahm Frequency Meters. Simple. Rugged. Unaffected by wave form or by ordinary voltage and temperature changes. Available for any frequency between 15 and 500 cycles per sec. Types for front-of-board or flush mounting. Bulletin 1415-I contains complete information.

JAMES G. BIDDLE CO.
ELECTRICAL INSTRUMENTS
1211-13 Arch Street Philadelphia, Pa.

INSTRUMENT MOTORS All Types — All Sizes



1/2000 to 1/6 Horsepower

Whatever your requirements, there is a Bodine motor to fit the job. The Bodine line includes split phase, capacitor, and polyphase induction and synchronous a-c motors; shaded pole a-c motors; shunt and compound d-c motors; and series universal motors. Also speed reducer and governor controlled motors. The finest instruments are Bodine equipped.

FREE
Motor Booklet

Bodine Electric Co.
2244 W. Ohio St., Chicago
Name
Company Title
Address
City State

BODINE

Ferrous Metal Detector

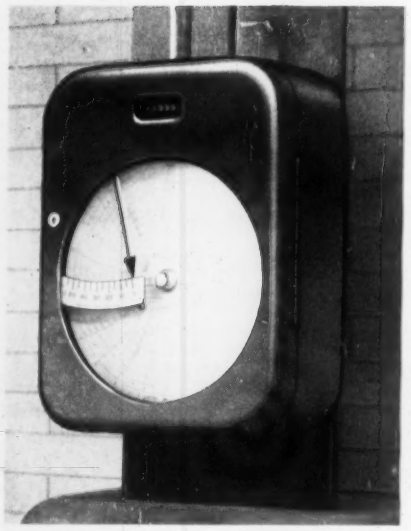
After years of use in penal institutions in preventing smuggling of guns, files etc., "Ahnor Forewarn Detector" equipment has been modified for in-

dustrial use to detect the presence of tramp iron or steel in various products or materials, in continuous or intermittent processes. In a simple intermittent search process, bundles or packages are passed by hand through search coil opening, and presence of iron is announced by visible and audible signals. Fully automatic protection can be obtained by installing metal detectors on conveyor belts; presence of tramp iron causes momentary reversal of the conveyor system. Detector consists of search coil, amplifier, and supervisory signals. Amplifier and signals may be made an integral part of coil system or they may be remotely located. Full supervision of operation is built into amplifier so that failure of tubes, transformer, relay or coil system is immediately revealed. A "micro control permitting easy adjustment of sensitivity of the search system" is standard. *Illinois Testing Laboratories, 172 W. Austin Ave., Chicago, Ill.*

Indicating Alarm Relay

New sensitive alarm relay, "Model 730," serves also as an indicator over a 0-4 milliamp. range. In standard type, relay makes contact at 1 and 3 ma. Other

ranges and contacting arrangements to order. Two types of cases: a flush, "bank-alarm" case, and a surface type. Each has removable front cover for adjustment of contacts or zero corrector. *Weston Electrical Instrument Corp., 581 Frelinghuysen Ave., Newark, N. J.*



Cochrane Meter with Orifice and Dual Transmitting Feature

HERE is an effective metering hook-up for dual use as, for example, where a plant generates steam and sells part to an adjacent plant. Duplicate Cochrane Recorders installed in each plant furnish duplicate records of the steam flow on separate charts and integrating.

Cochrane Electric Flow Meters provide accurate records of fluid flow any distance from the pipe lines. The galvanometer null principle guarantees precision measurements.

Write for Publication No. 2096 giving details of construction and operation.

COCHRANE CORPORATION
3120 N. 17th St. Philadelphia, Pa

COCHRANE
FLOW METERS

MOISTURE TELLER

Rapid and accurate moisture test in percentage by drying. Ideal for plant moisture control or laboratory moisture determinations.

Time required to dry most materials is one minute.

Suitable for granular—fibrous—crystalline materials in industries such as:

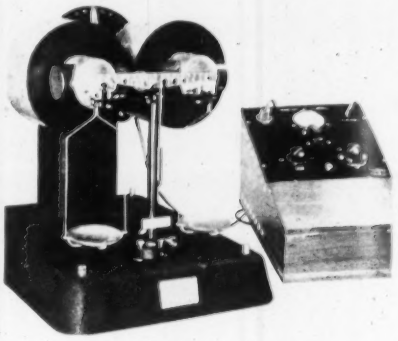
Sand Textile Tobacco
Ceramic Rubber Food
Wood Mining Leather

Write for Literature

Harry W. Dietert Co.
9330 Roselawn Avenue
Detroit, Michigan

Torsion Magnetometer

Designed primarily for measuring magnetic properties of materials in sheet form: transformer iron, silicon steel, etc., sensitive to rolling and to heat treatment. Makes it possible to follow changes

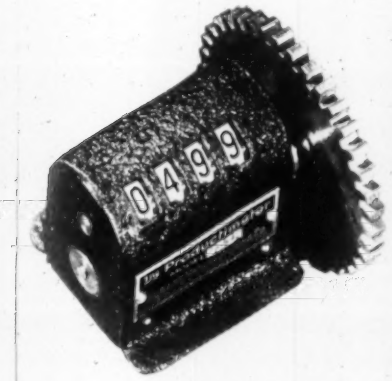


in these properties. On the balance beam of a sensitive balance is mounted a removable chuck in which the specimen to be studied (1" disk) is placed. Specimen is then mounted between the pole pieces of an electromagnet producing 3000 oersteds across a 1.5" gap with 1.7 amps. flowing in the field coils at maximum, to 800 oersteds in a 2" gap at 0.45 amps. (minimum value). Magnet is mounted on ball bearings and may be rotated through 180° with specimen at center of rotation. A scale (least count 1°) shows position of magnetic field with respect to an arbitrarily set specimen axis, usually the rolling direction. The balance itself has been made as non-magnetic as possible; is sensitive to 10 mg. By plotting unbalance against angular setting of the electromagnet, the axis of easiest magnetization of the specimen with respect to the direction of rolling can easily be determined. Relative response of specimen to rolling or heat treatment can be studied. Orientations and magnetic properties of single crystals can also be studied. The control (Rawson Electrical Instrument Co.) is designed for use on 110 volts d.c. and allows easy maintenance of current values. Instrument comes with punch for specimens, set of weights for balance, extra pans, etc. *Baird Associates, 20 Palmer St., Cambridge, Mass.*

New "Windowstat"

Radically different in appearance, new design of window condensation control

instrument (see *Instruments*, March 1938, page 62) is mounted normally as shown in illustration, is 5⅜" wide by 1¾" deep by 4½" high, including mounting bracket. *Julien P. Friez & Sons, Inc., Baltimore, Md.*



100 Standard Models of Registering Instruments

Among Durant *Productimeters* for registering strokes, revolutions, or lineal measure can be found the right instrument for almost any requirement in counting or measuring.

Ask our field or factory engineers for recommendations on any new or special counting problems you may have.

Productimeters
THE SPEEDOMETERS OF INDUSTRY

DURANT MFG. CO.
1930 N. Buffum St., Milwaukee, Wis.
182 Eddy Street, Providence, R. I.
Sales Offices in all principal cities

TELL US WHAT YOU WANT TO COUNT

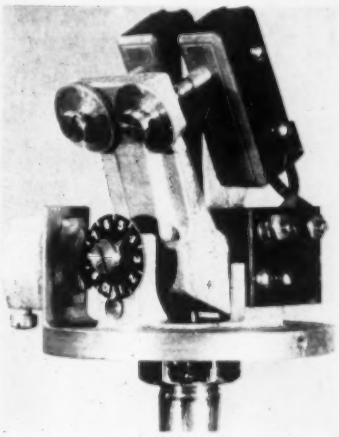
TEMPERATURE CONTROL

If you have temperature control problems, send for your copy of the new Blue Book Part 4 which describes thermoregulators and relays for industry and science, including new units accurate to 0.1 F. Application diagrams are included.

H-B INSTRUMENT CO.
2502 N. Broad St. Philadelphia, Pa.

Temperature Controller for 2- or 3-step Modes

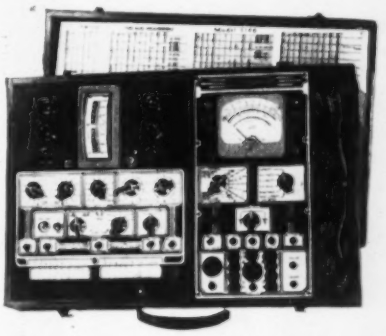
New "Model VD-H" is equipped with two snap-action switches, making it possible to secure two- or three-step control. Each switch has its own adjusting screw, in addition to main adjustment



for setting to desired temperature. Either or both switches may be: (1) Normally open—closes on rise in temperature; (2) Normally closed—opens on rise in temperature; (3) Three wire—single pole, double throw. Therefore, a large number of circuits can be worked out. Instruments may be set for any temperature up to 1400° F. Each unit has the usual BX cable connector and terminal plate for ease in making electrical connections. For temperatures up to 300° F., instruments may be equipped with ½" tubes up to 21¾" long. Standard practice calls for ¾" tubes up to 23¾" long. Adjustable ranges for approx. one turn of the adjusting screw are 300° and 400° F., depending on exposed length, temperature limit, etc. The "head" of Model VD-H has a round base 3½" in diam. and is 4½" high. Snap action switches are rated at 10 amps. for 110 volts a.c. and 5 amps. for 220 or 440. *Burling Instrument Co., 238-241 Springfield Ave., Newark, N. J.*

Combination Tester

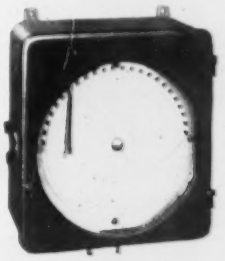
New "No. 5148" combines a complete tube tester with a wide-range set analyzer. Tube tester section is of dynamic mutual conductance type; set analyzing



section has a built-in multi selector with a complete set of leads and adapters for socket analysis. Ranges are said to cover every present need and many future requirements. *The Hickok Electrical Instrument Co., 10514 Dupont Ave., Cleveland, Ohio.*

RECORDS DRAFTS, PRESSURES AND DIFFERENTIALS . . . . . .

THE HAYS SERIES OT DRAFT RECORDERS



Here is an instrument sensitive enough to register accurately increments of .0025 of an inch water pressure, yet husky enough to stand severe use. In the STEEL INDUSTRY it is invaluable for maintaining proper atmosphere in soaking pits, annealing furnaces, open hearth furnaces, slab mills and any place where an accurate record of Draft, Pressure or Differentials is required. In the process industries there are many applications on driers, filters, kilns, etc. May be had in a portable case. Write for special literature. Dept. 11-2-8.

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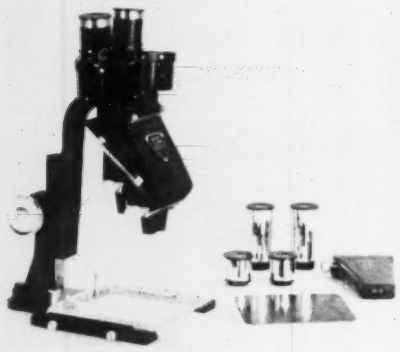
Binocular Microscope

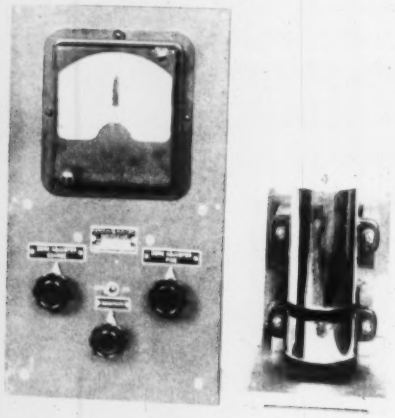
Introduced to meet the need for a somewhat smaller and lighter instrument of the Greenough type, a new wide-field microscope, Model K, is available in two



forms, for either reflected or transmitted light. Both forms are supplied with objectives and eyepieces to cover the general range of shop and school work. A dust-proof shuttle nosepiece carries in parfocal position any two pairs of objectives except the 0.39× and 0.7× objectives. Full range of objectives and eyepieces is available for working magnifications of 2.3I to 150 diam. Body is the regular Greenough binocular type, adjustable for interpupillary distance. Stage is equipped with removable glass insert and removable white and black metal plate, for proper contrast of object under investigation. Instrument can be placed directly on the work or it can be equipped with a base carrying a fork-mounted mirror for transmitted light, and a pair of arm rests to steady the hands while working on the specimen.
Bausch & Lomb Optical Co., 675 St. Paul St., Rochester, N. Y.

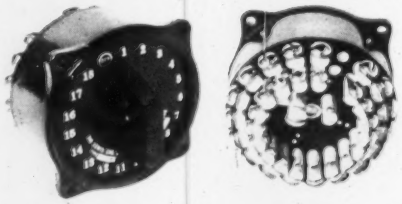
Electric Foil Gage

Problem of continuous measurement of thickness of thin foils during rolling without touching the foil has been solved in a new electric foil gage. Foil is passed



through an air gap $\frac{3}{8}$" wide. Eddy currents are induced in the metal foil as it passes through a high-frequency magnetic field and the effect of these currents on the field is measured to determine the thickness of the foil. It is said that thickness is indicated to accuracy of 0.00001".
—General Electric Co., Schenectady, N. Y.

ROTARY SELECTOR SWITCHES *for use with* **THERMOCOUPLES**



There is a "LEWIS ENGINEERED SWITCH" suitable for every multiple thermocouple installation.

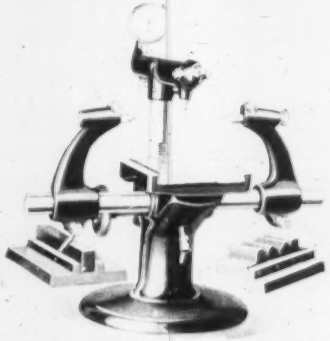
Every Switch has an "OFF" position. Every model is designed exclusively for the small voltages generated by thermocouples. Low contact resistance permits very accurate readings. Standard Stock Models.

Part No.	No. of Pos. besides "Off" Pos.	Nominal O.D.	Approx. Wt.
1IS	2, 3, 4	2.5"	7 oz.
10S	6, 9, 12, 18	3.0"	19 oz.
12S	24, 28	4.0"	25 oz.

Bulletin IS-37-17 On Request

THE LEWIS ENGINEERING CO.
NAUGATUCK, CONNECTICUT

Simplify
your Gauging
WITH THE NORTH SIDE



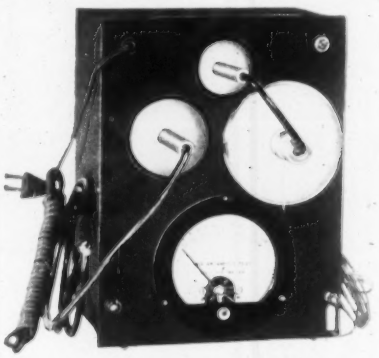
AMPLIFYING GAUGE

Used more rapidly than snap gauges and gives more useful results. Well adapted for use by unskilled labor. Handles all shapes, up to 5½" high on table and 8" in length between centers. All styles from universal (illustrated) to plain single-purpose models. Highest workmanship and best materials.

The North Side Tool Co.
17-19 Maryland Ave. Dayton, Ohio

Peak Kilovoltmeter

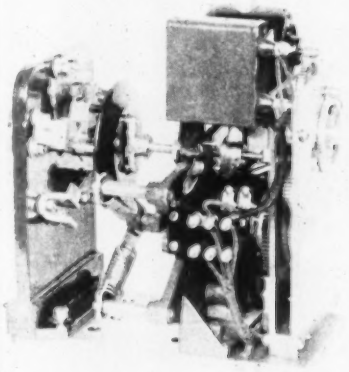
Though of the ordinary scale-and-pointer form, this new type of instrument indicates the maximum value of intermittent instantaneous peak potentials.



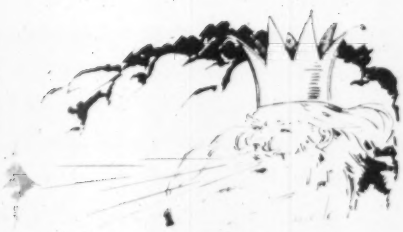
It consists essentially of a high-voltage rectifier in series with a capacitor and electrostatic voltmeter. Specifically, it measures "instantaneous maximum potential of the electron charges" accumulated on the plates of a newly-designed low-leakage capacitor permanently sealed in the voltmeter. Leakage resistance is approx. 10^{13} ohms. Variations in this resistance are said to have negligible effects on indications. Outstanding use is said to be direct and accurate measurement of instantaneous breakdown voltage developed by ordinary induction spark coils. Others are: p.d. between the first positive and first negative peaks of damped sine wave; surge voltages; maximum value of pulsating d.c. voltages, etc. Now available in ranges from 100 volts minimum readable value to 16,000 maximum; soon available for higher voltages.
—The Hickok Electrical Instrument Co., 1054 Dupont Ave., Cleveland, Ohio.

Voltage Regulators

A new switching mechanism in which the major insulation between taps and from line to ground consists of wet-process porcelain, has been incorporated



in a redesigned line of four-step branch feeder voltage regulators. The mechanism has a spring drive, actuated by a sturdy capacitor motor and gearing, with the gearing providing a time-delay between the operations of the contact-making volt-meter and switching mechanism. This time-delay is automatically reset by auxiliary switches which cause the motor to run back to its original position when a change in voltage is not required.
—General Electric Co., Schenectady, N. Y.



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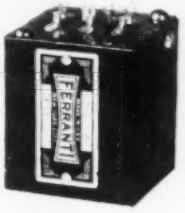
Telemetering System for Electrical Units

New features included in design of "Metameter" telemetering system (see *Instruments*, Feb. 1934, page 36; Jan. 1935, page 23) have made it practical to apply this system to electrical measurements, using standard measuring elements in the transmitter. Indications of millivolts, or of the totalized megawatts of power plants, can thus be indicated or recorded at distances from a few feet to many miles.—*The Bristol Co., Waterbury, Conn.*

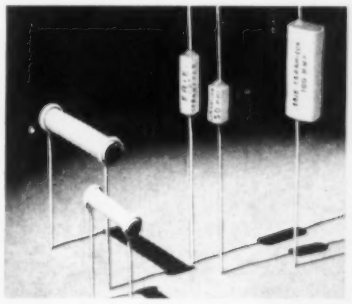
Miniature Transformers

New miniature transformers, the "Aero Series," are particularly suitable for the communications and electronics fields in that they are light in weight and extremely small in size; overall dimensions including reversible mounting arrangement are 1¼" × 1¼" × 1½" high. Core materials are nickel iron alloys. Coils are of moisture-proof construction for marine and aeronautical service. Transformers have a usable range from 20 to 20,000 c.p.s.; are available in input, interstage, output, bridging and mixing types; have an operating level from −80 to +22 db and a special group is included which is capable of passing plate current when used over the voice range.—*Ferranti Electric, Inc., 30 Rockefeller Plaza, New York City.*



Fixed Capacitors

New "Ceramicons" consist of a ceramic dielectric with coated plates of pure silver. Capacity constancy is said to be such that 600 hours of alternations between 40° F. and 250° F. causes <0.25% change. Increase in power factor <20% and change in capacity <0.25% after 100 hours at 100% humidity, 40° C. Capacity is independent of frequency. Rating is 500 volts d.c. One type has a positive and another a negative temperature coefficient. By combining them in one unit (as shown at the right) any temperature coefficient between the limits of the two individual units may be obtained. Size of unit is approx. 1" × 1½".—*Erie Resistor Corp., 653 West 12th St., Erie, Pa.*



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"THIS BOOK reflects the amazing development in large-scale power transmission which has taken place in Great Britain during the past decade under the Government sponsored "Grid" system. The subject matter falls into five main divisions: (1) protective transformers, (2) the interconnection of these transformers to form protective circuits, (3) relays, (4) modern methods of protecting electrical apparatus, and (5) the testing of relays and protective circuits . . . The volume is liberally illustrated; the material is logically presented in a lucid manner; and the whole provides a concise treatment of a subject upon which it has heretofore been difficult to collect comprehensive data without extensive reading in diversified publications."

—PERRY A. BORDEN

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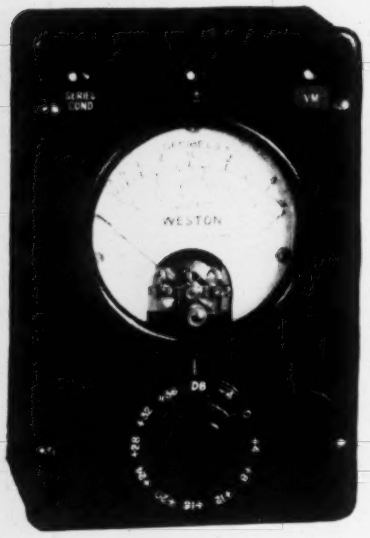
Special Apparatus Built to Order

Decibel Meter

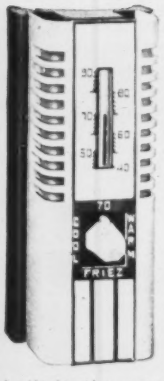
A rectifier-type power level indicator and voltmeter, "Model 695 Type II," in which a new circuit network is said to provide improved uniformity of operat-



ing characteristics, has a constant internal resistance of 20,000 ohms, both into the instrument from the line under test, and from the instrument into the network toward the line. This feature makes it possible to make all db ranges track on a single scale. Indicator has two scales (multiples of 2 and 5) to facilitate readings on voltage ranges: 2, 5, 8, 20, 50, 80, and 200 volts. Movement is of medium speed, damped for general service. In common with previous types of "Model 695," instrument is adjusted for a zero signal level of 0.006 watt in a 500-ohm line; indicates from −8 to +32 db at zero on the db scale, or a total spread of 55 db. Unit consists essentially of a rectifier type, 2½" scale indicating instrument, range-changing switch, the required internal network, a blocking capacitor, jack-type output terminals, and two 4-ft. leads complete with test prods. — *Weston Electrical Instrument Corp., 581 Frelinghuysen Ave., Newark, N. J.*

Thermostat with Half-degree Differential

New "Microstat" line of thermostats with 0.5° F. minimum differential (adjustable by user) is especially designed for use on low voltages (25 volts) yet is rated for 75 watts directly off contacts without recourse to relays. It measures 3½" high, 1½" wide, 4½" deep; incorporates new "Alnico" sintered magnet, pure silver snap-acting contacts and heat-treated and seasoned bi-metal elements. Case is of pressed metal (ivory or silver finish), ventilated for sensitivity, includes a built-in thermometer. *Julien P. Friez & Sons, Inc., Baltimore, Md.*



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GRAVITOMETER

An accurate record of the specific gravity of gas.

Compensated for temperature and barometric pressure variations.

A number of different ranges available.

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Portable Potentiometers

RUBICON portable potentiometers are available in a variety of models and ranges to suit any application, such as pyrometry, pH measurements, meter calibration, etc. These high-grade instruments are described in Bulletin 270.

RUBICON COMPANY
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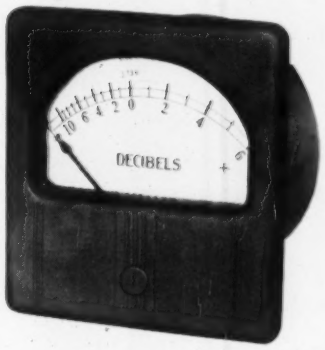
Potentiometers. Galvanometers. Electrometers. Colorimeters. Permeameters. Arcconographs. Resistance Boxes. Wheatstone and Kelvin Bridges. Coil Testers. Clip-on Transformer Ammeters.

Bulletins available on request

Power Level Indicators

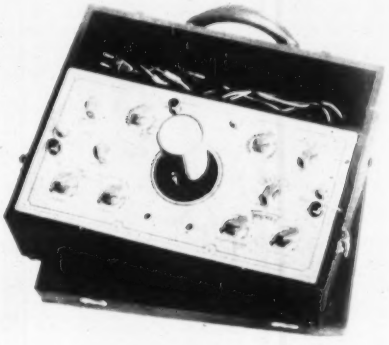
New miniature instruments for measuring levels of a-f. signals consist essentially of modified permanent-magnet moving-coil movements in conjunction with selected Rectox rectifiers. Special attention is given to the control of response and damping characteristics of the movements. All standard indicators



have scales marked −10 0 +6 db; others can be furnished with special scales, speed, response, damping and calibration. Due to characteristics of copper oxide rectifier, it is not desirable to make power level indicators for levels lower than 0 db + 0.548 or 0.6 volts, maker states. Standard Power Level Indicators are available in (1) "Standard Speed": natural period of approx. 0.57 sec.; damping factor of 2; (2) "High Speed": natural period of approx. ⅛ sec.; damping factor of 16.6; light moving element, strong control springs and a strong cobalt steel magnet. Available in round flush, rectangular flush, and rectangular projection mountings. — *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

"Turret" Oscilloscope

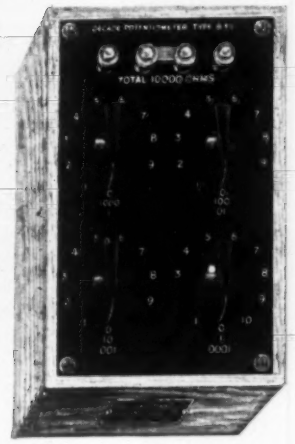
Two new oscilloscopes, with 2" and 3" screens, incorporate an exclusive turret tube mounting which permits easy adjustment of tube up or down, or to either



side, to make screen face operator. An adjustable shield is said to enable "easy reading in brightest daylight." These two oscilloscopes are said to meet every requirement for visual study and adjustment of circuit problems. Linear sweep from 15 to 20,000 cycles. Model 1690 oscilloscope (illustrated) is furnished in deluxe leatherette, or metal with black wrinkle finish. The 3" oscilloscope, slightly larger, comes in metal case only. — *The Triplett Electrical Instrument Co., 321 Harmon Ave., Bluffton, Ohio.*

A New
Shallcross Instrument

The No. 835 Decade Potentiometer is a precision voltage divider and can be employed as an auxiliary to the laboratory precision potentiometer.



Provides Voltage Ratios of 0.0001 to 1.0

Schools and colleges will find it ideal for student instruction and industrial laboratories will also use it for calibration of galvanometers and voltmeters.

Send for Bulletin 835-H describing this new instrument.

SHALLCROSS MFG. CO.
COLLINGDALE, PA.

Vernier Caliper

New model of Mauser Vernier Caliper is made entirely of a special grade of stainless steel which will not tarnish in damp atmosphere or when moistened by

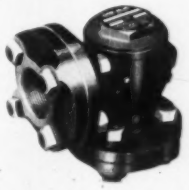
the most acrid perspiration, and is capable of being hardened to a high degree. Measuring surfaces have a Rockwell hardness of 55 or more. *George Scherr Co., 130 Lafayette St., New York City.*

Stopcock Greases

Four types of grease are announced for use on glass cocks in vacuum lines. No. 6 is for cocks which may be subject to high temperatures. No. 7 for high-vacuum exhaust systems, will not readily release gases which would interfere with vacuum readings. No. 8 lubricates rubber hose connections to metal tips of vacuum exhaust pumps and assists in making such joints vacuum-tight. No. 10's light consistency makes it most suitable for atmospheric pressure use and for easier manipulation when cold. It is particularly adapted to dessicator use. *Westinghouse Electric & Mfg. Co., East Pittsburgh, Pa.*

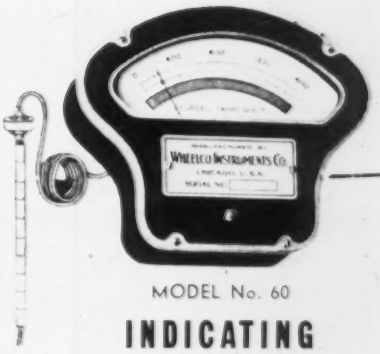
Angle Valve

Introduction of this new angle flow valve rounds out line of controls for improving circulation on hot-water heating systems. It acts both as a flow valve and elbow (additional flow valve is not required in a single return system); contains a new valve disk construction that balances the pressure head to assure against leakage from gravity circulation. Body material is brass for the 1" size and cast iron for the 1½" and 2" sizes with brass trim for all sizes. *Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*



Refrigerator Control

New "TAG Snapon Control, Type R-10," for domestic refrigerators, retains many features of older models; is of simplified construction; is said to have new advantages. Stainless steel frame rigidly supports working parts and insures against creep of temperature settings, while the side plates can be removed easily for inspection of internal parts. A novel idea is introduced for operating the "On-Off" switch by means of the cold control knob. Replaceable tube system is new; by removing four screws, complete bellows cup assembly may be replaced. Differential setting can be changed by inserting a small screw driver through hole in adapter screw, without removing control from evaporator baffle. *C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*



MODEL No. 60

INDICATING PYROMETER

Wheelco Model No. 60 is equal in performance to the highest priced instrument on the market—high resistance—ruggedly constructed for long service—dust and moisture-proof case—equipped with automatic compensation—4½" mirrored scale, and choice of ranges and calibrations. It is an easy to read, accurate indicating Pyrometer that can be relied upon for efficient service.

Includes 12" Thermocouple and 5 feet lead wire

See Bulletin No. 504-G For Other Types & Sizes — PRICE $45

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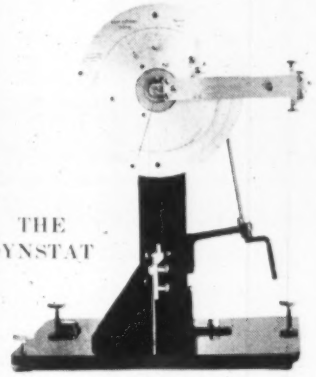
Special Tester for PLASTICS



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SPECIALLY designed for test procedures recommended in a German Government Materials-testing Bureau Report (which disclosed erroneous results of applying classical hard-material laws and ordinary procedures to mechanical testing of plastics).

Permits making every mechanical test to which makers and users of insulators and other molded materials attach significance: impact strength, bending strength, static bending strength, impact bending strength, etc.

This is but one of an extensive line of special testing machines representing the new, **correct** techniques. Write for bulletins concerning **your** problems.

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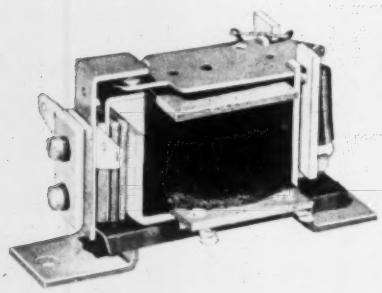
WHEELCO Portable Potentiometer

- Specially designed for field and laboratory use.
- Hand drawn millivolt scales, or temperature scales in Fahrenheit, Centigrade, or both.
- Accuracy and sensitivity is far higher than any temperature calibrated pyrometer.
- Made in four different models, having special equipment for different classes of service work.
- Complete data and information furnished on request.

Wheelco Instruments Co.
1933 So. Halsted St. Chicago, Ill.

Relay

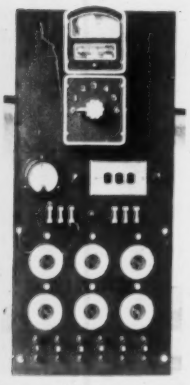
New "Type D" electromagnetic relay for operation on either a.c. or d.c. measures $2\frac{3}{8}$"x$1\frac{5}{16}$"x$1\frac{1}{2}$". With a-c. coils it is furnished for use up to 120 volts, and



with d-c. coils up to 60 volts without series resistors. Contact capacity is 10 amps. a.c. and 2 amps d.c. Contact pressure and contact travel are adjustable. Solder lugs are provided for coil terminals and contact connections. Frame and armature are made entirely of silicon steel to minimize heat losses on a.c. Available with one pair or two of normally open contacts; one or two of normally closed; one s-p.d-t.; d-p. contacts normally open or normally closed, or d-t. where two poles are common. The d-c. relay can be furnished with a slow-acting armature to give a delay up to 5/100 sec. on either pick-up or release time. It can be furnished for operation in the plate circuit of a vacuum tube with a coil resistance up to 2000 ohms and operating current as low as 2 ma.—*G-M. Laboratories, Inc., 1731 Belmont Ave., Chicago, Ill.*

Utility Test Panel

Designed for making routine and trouble tests. Six devices can be put on test at one time. A complete set of readings can be taken for each device separately, while they are on test. The following determinations can be made: (1) Surface temperature or internal temperature (up to 800° F.); (2) Resistance from 0 to 1000 ohms; (3) Continuity current readings as low as 10 milliamps. Test prods enable user to check resistance of any part of unit circuit; also to determine resistance from element to ground on any device. Panel carries an indicating pyrometer and 6-point switch; is wired for taking resistance readings. There are also a "small throw switch," two outlet receptacles, a pilot light, and a milliammeter (protected by a small fuse). Appliances to be tested are plugged into any of the six power output receptacles. These are in no way connected to any instrument on the panel. Six sets of binding posts at bottom of panel are connected to indicating instrument through the 6-point switch. To them are connected suitable thermocouples, etc.—*Wheelco Instruments Co., 1933 South Halsted Street, Chicago, Ill.*



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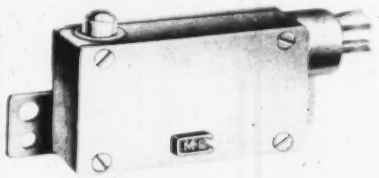

standard Micro Switch carrying Underwriters' and Hydro-Electric Power labels, rating it at ½ h.p. up to 460 volts a.c. Sealed into steel case, switch is actuated by a plunger. Total travel of plunger is ¼" but switch is actuated by a movement of 0.001" in the forepart of this travel. The exact point of plunger travel at which actuation occurs is said to be maintained over millions of operations even though plunger may be actuated by hammer blows or allowed to snap off a cam. Dimensions $2\frac{3}{4}$" × $1\frac{9}{16}$" × $\frac{15}{16}$".—*Micro Switch Corporation, 15 E. Spring St., Freeport, Ill.*

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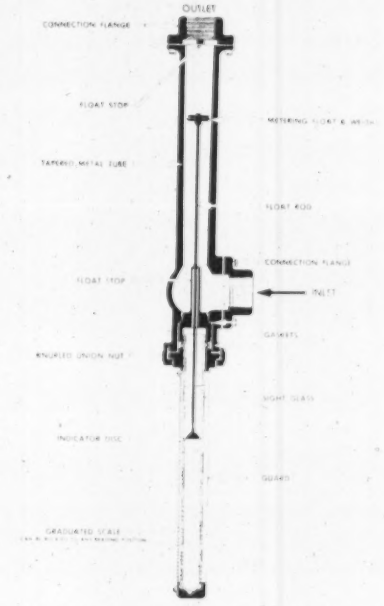
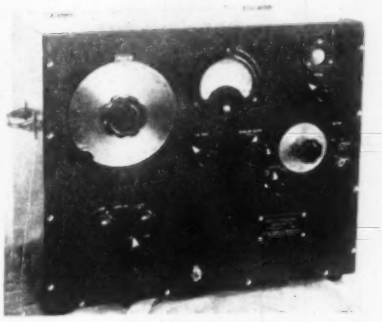
"Flowscope" flow indicator, for air or gas up to 20 lbs./in.² line pressure, is of "area" class, cone-and-disk type, rod-guide-float variety. Is available in single



and dual mountings, the latter having adjacent scales for conveniently comparing two rates of flow in applications requiring maintenance of ratios. Tapered-bore tubes are said to be of high precision. Equal changes in flow rate produce equal changes in float position. Scales may be turned 360° to face in most convenient direction. Available in capacities (N.P.T. air basis) from 30 to 5000 ft.³/min. For butane approx. ¾ of air capacities. Scale lengths are $5\frac{3}{8}$" (for capacities up to 1000 ft.³/min.) and 9" (0-250 minimum).—*The Selas Co., 18th St. at Indiana Ave., Philadelphia, Pa.*

Beat-frequency Generator

New portable instrument delivers a continuously variable a-c. voltage from 100 mv. to 10 volts over two continuously variable frequency ranges from 20 cycles to 20 kc. and from 20 kc. to 5 Mc. Has direct-reading frequency dial with well expanded scales, direct reading output



voltage attenuator system. Exceptional stability is said to be attained through correct circuit design, rigid construction and good thermal insulation. Low temperature coefficient condensers and coils are used in all frequency-determining circuits. Specially designed broad band amplifier provides substantially constant output over major portion of entire frequency range. Each frequency range is independently adjustable for zero setting, permitting switching between ranges without resetting. — *Boonton Radio Corp., Boonton, N. J.*

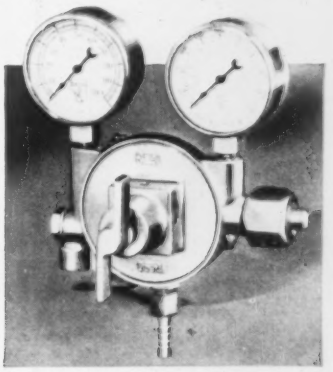
Inkless Recorder

The conventional inking system has been replaced by a mechanism utilizing a typewriter ribbon as the marking medium in a new recording electrical

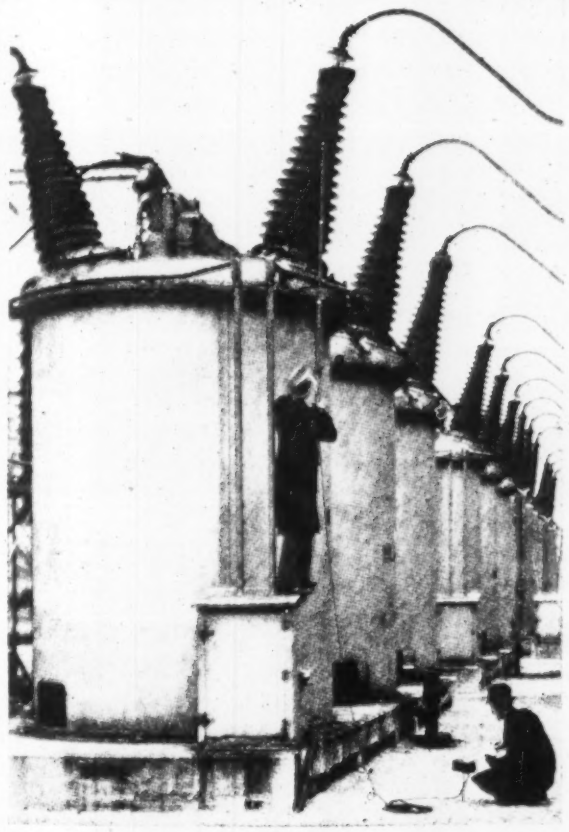
instrument, eliminating spillage, evaporation, freezing, clogging of pens, etc. New instrument offers also, it is said, such advantages as increased reliability over a wide range of temperature, added accuracy since pen-to-paper friction is reduced, decreased maintenance, and ability to obtain a month's record without servicing. — *General Electric Co., Schenectady, N. Y.*

Two-stage Regulator

New "Regolator" two-stage regulator combines a "positive, direct" first stage nozzle type regulator and a second stage inverse or stem type regulator; is said to provide constant flow of gas regardless of cylinder pressure fluctuations from full to empty. Its newly



designed triple filter cartridge type strainer is said to have a filtering area at least 17 times as great as that contained in ordinary regulators; also serves to dissipate heat and eliminate possibility of seat ignition. First stage regulator setting 150 lbs./in.² or adjusted by the operator to as low as 75 lbs./in.²; second stage regulator adjustable from 0 to 75 lbs./in.² delivery pressure; constant delivery pressures well below 1 lb./in.² are said to be easily maintained. — *The Bastian-Blessing Co., 230 East Ontario St., Chicago, Ill.*



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Modern Scratch Hardness Methods

Thirteenth instalment of "Hardness and Hardness Measurements." See page 4, Jan. 1937 issue

By S. R. WILLIAMS
Professor of Physics, Amherst College

STUDY OF MOHS' SCALE BY MEANS OF MICROCHARACTER

A great many investigators have attempted to standardize Mohs' scale of hardness in terms of some particular hardness measuring device. Hodge and McKay[9] have studied the hardness of the minerals comprising the Mohs' scale by means of the microcharacter. Attention has already been called to the fact that minute crystal structures may be readily measured by means of this instrument. Thus in a sample whose crystal grains are arranged as in Fig. 77 it is possible to measure variations in hardness from one grain to another, a procedure which would not be possible with the general type of hardness testing instrument.

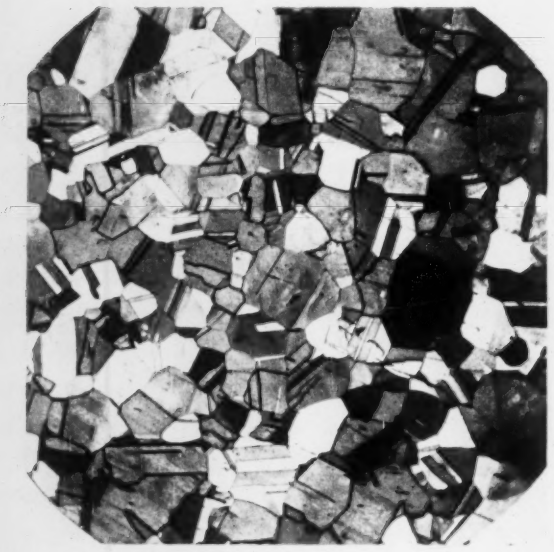


Fig. 77. Crystal grains in a phosphor bronze sheet. (annealed). Composition, approx. 95.50 copper, 4.30 zinc, 0.20 phosphorus. Magnification 75 ×.

Courtesy American Brass Co.

In the study of Mohs' scale, Hodge and McKay found values for the various steps as shown in Table II. The variations in each step and thus for each kind of mineral could be ascribed to changes in composition, changes produced by variously oriented crystal grains in the aggregate, and to changes in the directions in which the microcut was made with respect to the crystal faces and planes of cleavage of the crystal as a whole.

In this connection a paper by Jaggar[10] is of interest. It classifies instruments and inventors in an unusual way and gives a good bibliography up to the date of writing. Like the Grade-o-meter, described in previous pages,

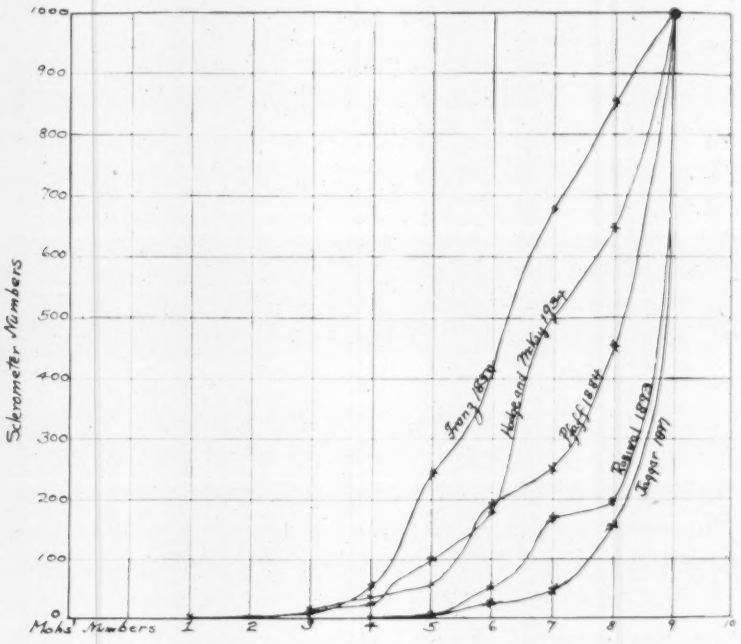


Fig. 78. Comparison of Mohs' Scale with various Sclerometers.

Jaggar's sclerometer depends upon a drilling process with a diamond point of prescribed form and dimensions. "The principle of the instrument is as follows: A diamond point of constant dimensions is rotated on an oriented mineral section under uniform rate of rotation and uniform weight to a uniform depth. The number of rotations of the point, a measure of the duration of the abrasion, varies as the resistance of the mineral to abrasion by diamond: this is the property measured."

This is strictly an abrasive method and could have been discussed under that head. It is introduced here because of the comparative study Jaggar made of the sclerometric values of Mohs' scale. Not only did Jaggar measure the relative values of Mohs' scale by means of his own sclerometer, but he compared these values with those of other observers. In Table III are given the values which he compares to which have been added some early values by Franz[11] and the more recent values

TABLE II SHOWING RELATIONS BETWEEN MOHS' SCALE AND MICROHARDNESS NUMBERS

The variations in microhardness of the materials is due to variations in texture, impurities, and anisotropy.

Materials	Mohs' Scale	Range of Microhardness		Average by C. Hodge and J. H. McKay
Talc	1	0.8	21.5	1
Selenite	2	10.2	56.6	11
Calcite	3	126	135	129
Flourite	4	138	145	143
Apatite	5	870	1740	577
Orthoclase	6	2100	2500	975
Quartz	7	2066	3906	2700
Topaz	8	2770	4444	3120
Corundum	9	3906	8264	5300

(*American Mineralogist*, Vol. 19, No. 4, April, 1934)

[9] T. A. Jagger, A Microsclerometer for Determining the Hardness of Minerals, *American Journal of Science*, Vol. 4, 1897, pages 399-412.

[10] R. Franz, Ueber die Härte der Mineralien und ein neues Verfahr dieselbe zu messen. *Poggendorff's Annalen*, Vol. 80, 1850, pages 37

TABLE III—MOHS' SCALE STANDARDIZED BY VARIOUS SCLEROMETERS

	Franz 1850	Pfaff 1884	Rosiwal 1893	Jaggar 1897	Hodge and McKay 1936
1 Talc			0.04		0.2
2 Gypsum	2.2	12.0	2.0	0.04	2.0
3 Calcite	13.2	15.3	5.6	0.3	24.0
4 Fluorite	52.0	37.3	6.4	0.8	27.0
5 Apatite	240.0	53.5	8.0	1.2	109.0
6 Orthoclase	400.0	191.0	59.2	25.0	184.0
7 Quartz	680.0	254.0	175.0	40.0	509.0
8 Topaz	860.0	459.0	194.0	152.0	645.0
9 Corundum	1000.0	1000.0	1000.0	1000.0	1000.0
10 Diafiond					

of Hodge and McKay both reduced to the same scales as the others. These results have been brought together in a series of curves in Fig. 18. The curves only go to show that the same property is not being measured in all cases. Jaggar's sclerometer is distinctly on the abrasive side of hardness testing and the most recent of methods uses a cutting edge.

Fig. 79 shows Jaggar's instrument attached to a Fuess microscope.[13] Fig. 80 gives the plan, while Fig. 81 shows the vertical elevation. Complete arrangements are provided for counting the number of rotations of the dia-

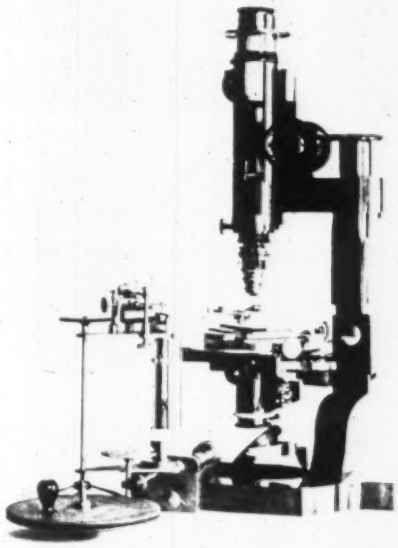


Fig. 79. This form of sclerometer depends upon the depth of depression which a diamond point will drill in the surface of a test piece when the diamond is rotated a certain number of times.

mond as it drills into the surface of the material tested. The instrument described admits of measurement with any one of the four variables, rate, weight, depth or duration. The last was found most practical, because it gives the highest values and hence admits of the most delicate graduation. Pfaff[13a, 13b] has worked along similar lines.

Attention was called to Auerbach's attempt to measure the hardness of glass. Since his day great improvements have been made in sclerometers and attention has once more been paid to the measurement of the hardness of glass.

Among the most recent studies is an article by Gehlhoff and Thomas[14]. These investigators used a Martens sclerometer and measured the scratch hardness of various glasses as different constituents were introduced or substituted for other substances. The diamond point had a 90° cone angle and the surface of the glass specimen was drawn under the diamond. They found it easiest to put a fixed load on the diamond point and measure the

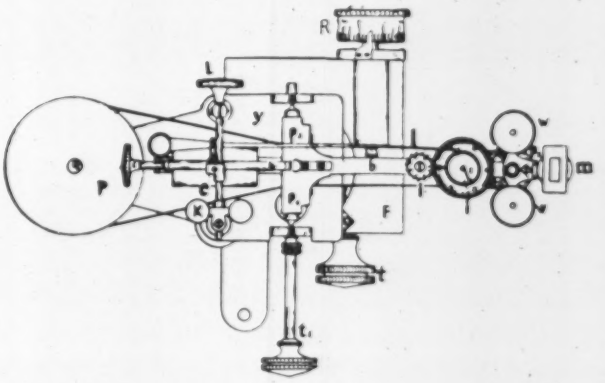


Fig. 80. Horizontal plan of a device for centering and rotating the diamond point drill.

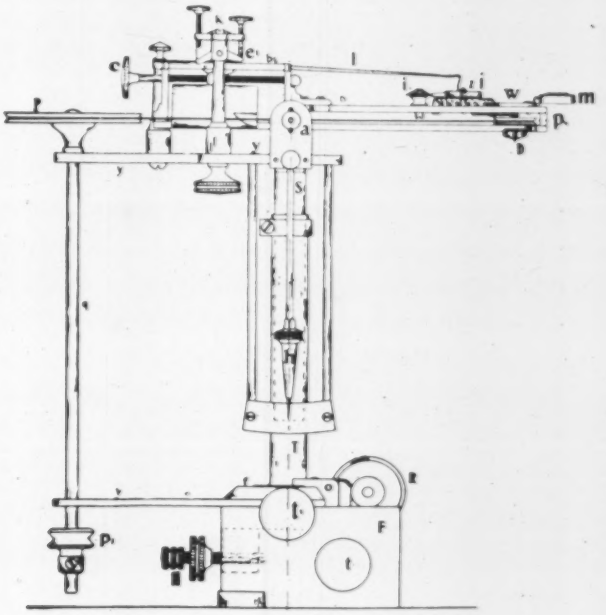


Fig. 81. Vertical elevation of device for centering and rotating the diamond point drill.

scratch width. They considered the hardness as the reciprocal of the scratch width given in 1 mm. The diamond point was always under a load of 20 kg. With heavier loads the scratches showed shell-like cracks. Lighter loads gave such faint scratches that their widths were not easily measured. A load of 20 kg. gave a width of scratch which varied from 0.0039 to 0.0091 mm. for

(Continued on page 76)

[13] F. Pfaff. Versuche die mittlere Harte der Krystalle mittelst eines neuen Instruments, des Mesoskleometers, zu bestimmen. *Sitzungsberichte der physikalisch-medizinischen Societat in Erlangen*, Vol. 15, 1883, pages 18-23.

[13a] F. Pfaff. Untersuchungen uber die absolute Harte des Kalkspathes und Gypses und des Wesen der Harte. *Sitzungsberichte der mathematisch-physikalischen Klasse der Bayerischen Akademie der Wissenschaft zu Munchen*, Vol. 3, 1883, pages 372-400.

[14] G. Gehlhoff and M. Thomas. The Physical Properties of the Glasses and their Relation to the Composition. *The Glass Industry*, Vol. 10, 1929, pages 140-145.

Cathode-Ray Oscillograph Applications

Twenty-ninth part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

RADIOPHONE TRANSMITTER TESTS

MODULATION STUDIES

One of the earliest and most popular application of cathode-ray tubes is the determination of the operating characteristics of radio transmitters, such as the percent modulation, phase shift, frequency modulation, hum level, parasitics, overload distortion, etc. Of these the most common test is the determination of the degree of modulation. Much information beside modulation is obtained from the resulting oscillograms. Also, since there are several accepted test methods, engineers charged with the care of a radio transmitter usually test all methods before selecting the one adapted for their own particular needs.

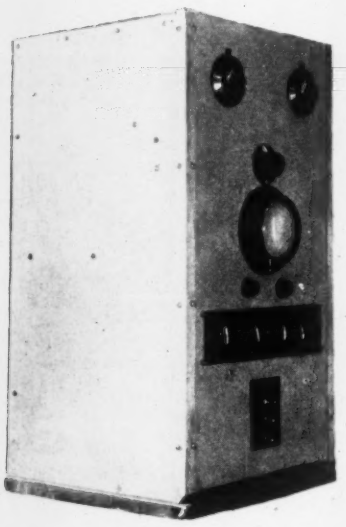


Fig. 1

The harmonic distortion that is usually tolerated in a broadcasting station may be under ten percent, which may impose severe restrictions in the permissible upper value of the percent modulation.

The popularity of cathode-ray tubes in this work is partly due to the relative simplicity of the whole test set-up, compared with other methods, since a time base sweep oscillator is not required. The actual cost of a cathode-ray tube and its controls is but little more than that of an ammeter. In fact an oscillograph can be made to take the place of several instruments, in the matter of giving equal amounts of information as to circuit operation. The deflection system canont burn out in case of overloads, and the "pointer" cannot wind up around the "peg" under similar conditions so that it is actually more fool-proof.

To test these conditions the author built a radiophone transmitter, Fig. 1, in which an oscillograph replaced all instruments. The power stage used two RK-20 tubes so that ample power was available. It was found that the efficiency of all stages, changes in the power output, modulation linearity, overload distortion, antenna loading, etc., were immediately apparent, since a switching arrangement coupled the deflection system to any part of the transmitter desired. As to the relative cost (compared with instruments) the entire outlay comprised a cathode-ray tube, a multi-contact switch and two control rheostats, since the high-voltage supply for the cathode-ray tube (1250 volts) was taken from the main power supply of the set.

MODULATION TESTS

Fig. 2 shows a number of test methods that are easily set up and used. In Fig. 2a the modulated r-f potential, picked up by a coil (E) loosely coupled to the antenna circuit, is applied to a "rotator" circuit, where the *L C* circuit is tuned somewhat off resonance, so that a circular diagram is obtained (as at 2a'). A similar arrangement is shown in Fig. 2b, wherein the condenser C_1 is tuned so as to give a circular diagram. When the transmitter is modulated, this circle changes in diameter so that a solid (torus shaped) diagram appears. Any linear distortion will alter the shape of this circle, and give a distinct indication of some misadjustment. However the circuit commonly used in modulation tests is the one shown in Fig. 2c. Here a comparison is made between the modulated carrier wave and the modulation potentials directly. This method produces the frequently described trapezoidal figure, shown at 2c'.

Actually this figure is a diagram of one half cycle of the modulator frequency but due to the fact that the horizontal deflection is at all times proportional to the modulation potential the sloping edges of the figure obtained with this method will be linear as long as there is no amplitude distortion present. In Fig. 2c' the edges are shown curved, as will be described later.

In a third method, Fig. 2d, the radio-frequency pick-up coil coupled to the modulated output circuit is connected directly to the vertical deflection plates. Another

Although the subject-matter of this instalment pertains to the radio industry, Ralph Batcher deals with it in so broad a way that readers in all industries will find it applicable to some of their special problems.

...d likewise is coupled to an intermediate (unmodulated) stage and is connected to the horizontal plates. Or else the horizontal plates can be connected directly to the radio-frequency portion of the crystal oscillator stage through a small capacitor to produce a deflection equal to the instantaneous value of the radio-frequency potential. In the case where the transmitter is unmodulated a straight line appears on the screen, but in many cases the line may be curved and in some sets may be an ellipse. The elliptical effect is due to a phase shift between the two points of pick-up (a condition that in itself is not indicative of poor operation). This ellipse can be converted to a line by altering the phase of one of the potentials, as by tuning the pick-up coil. Assuming that such a phase conversion is made, it may then be found that the resulting line appearing on the screen is curved. This curve, then, is in reality the resultant of all the characteristic curves of the transmitter tubes, and curvature simply indicates operation of one tube (or more) on a non-linear portion of its curve.

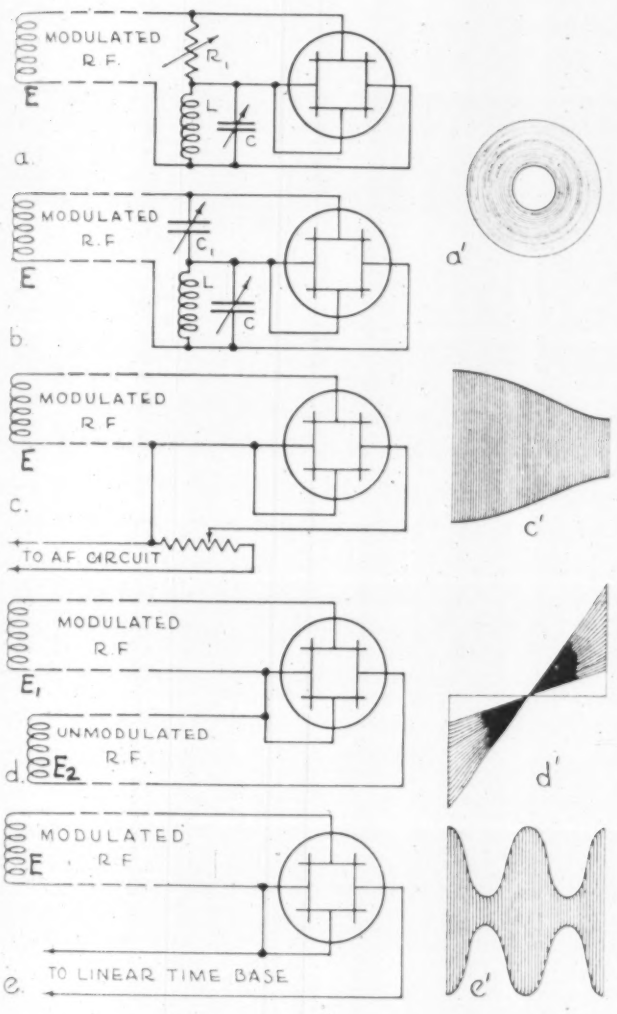


Fig. 2

When the transmitter is modulated, the line pivots around its center and produces a "solid" double triangle, as shown in Fig. 2d'. This diagram will indicate a phase shift due to power supply regulation troubles or other troubles, if elliptical effects appear at the edge of the diagram upon modulation.

In a fourth method, a linear time base operating at an audio frequency (preferably bearing some relation to the modulation frequency) is connected to the horizontal deflection system. The resulting diagram is a portion of the carrier frequency envelope, as in Fig. 2e'.

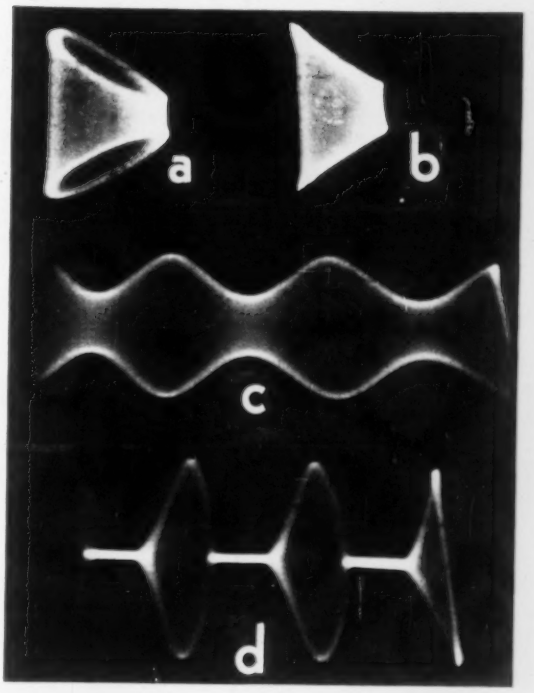


Fig. 3

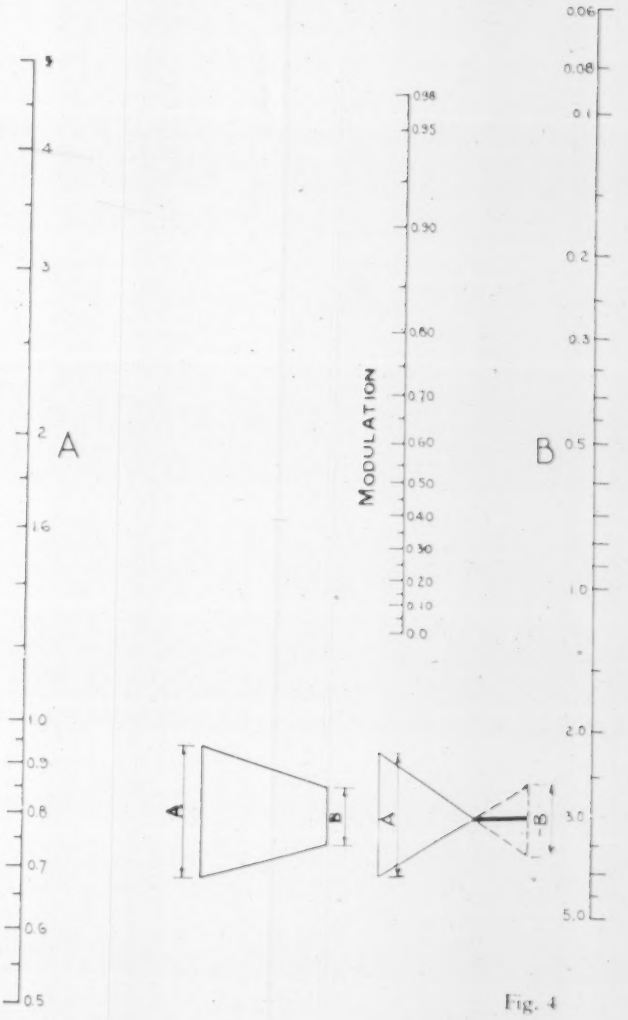


Fig. 4

Actual oscillograms of this type are shown also in Figs. 3c and 3d (General Radio Co.). An oscillograph connected in this way is frequently used as a volume indicator in monitoring radiophone transmitters, since it indicates the particular types of voice or musical passages that cause blasting. In any of the above methods the radio-frequency carrier can be rectified by a suitable linear detector, so that only the envelope of the aforementioned oscillograms appears on the screen. In following out this process it will be necessary to delineate the horizontal axis of the oscillogram in order to permit measurements to be made. This can be done by temporarily removing the vertical deflection potential.

COMPUTATION OF PERCENT MODULATION

In the modulation oscillograms shown in Fig. 5 the maximum and minimum deflections have been labelled A and B respectively. The classic formula commonly used in converting such values to the percent modulation is

$$M = \left(\frac{A-B}{A+B}\right) 100\%$$

Substitute the distances scaled from the diagram in any units of length. Or else these values can be applied to the chart, Fig. 4, and the percent modulation determined therefrom, by finding the intersection on the central scale of a line drawn from the values of B and A.

In any of the above modulation studies, however, it should be remembered that no single value of percent modulation will tell the whole story—especially if the amplifier is not linear, or if the system does not modulate "down" the same as it modulates "up". This is graphically shown in Fig. 5 where three examples of the trapezoid type of modulation diagram are shown. In Fig. 5a, the sides (AB) of the diagram are linear, and the distances AC and C′B are equal. Here the shaded portion CCC′C′ is the carrier wave oscillogram when it is unmodulated, and AABB represents the modulated carrier. In Fig. 5b the sides are sloping and the distance AC is greater than C′B or the transmitter "modulated up." In Fig. 5c the reverse is true. The usual definition of percent modulation refers to the average value of the positive peak and negative peak modulation, and is closely represented in the above formula and chart.

CONNECTING TO THE TRANSMITTER

The connections shown in Fig. 2 utilize pick up coils coupled to the transmitter in some manner to collect the required amount of radio frequency energy to deflect the ray. The deflection amplifiers found in some oscillograph units, however, are of no value at such frequencies so that sufficient potential must be available to operate the deflection directly. In many cases an easier method is to mount a short length of high-tension cable, such as ignition cable, near a high-frequency bus-wire in the transmitter and to connect it directly to one deflection plate, the mate of which is grounded. These plates should be shunted by a radio-frequency choke or by a high resistance.

In low power stages where the energy level is sufficiently low, the deflection plate can be connected directly to the stage through high-voltage low-capacity condensers, the value of which is not large enough to disturb the natural operation of the circuit.

In obtaining audio-frequency potentials for deflection purposes, it is possible to connect the deflection plate to an audio or modulator stage through small condensers. It may be found, however, that with these connections the audio potential applied to the deflection plates is not in phase with that used to modulate the transmitter. In this case the modulation oscillogram may appear somewhat as in Fig. 3A where the sloping edges are elliptical. In order to make accurate measurements the phase should be shifted to the normal one, so as to bring the narrowest part of the figure to the extreme edge of the diagram.

This shift can be brought about by inserting a high resistance in the lead connecting the audio-frequency potential to the deflection plates, and then shunting the deflection plates with an appropriate condenser, the capacity of which is selected by experiment. In other cases the condenser can be inserted in the connection lead and a shunt resistance used. Figs. 3A and 3B show the modulation diagram before and after phase correction. In Fig. 6 oscillograms are shown (43 and 44) in which some audio distortion is present, since the edges never appear straight even after correction. No. 42 in

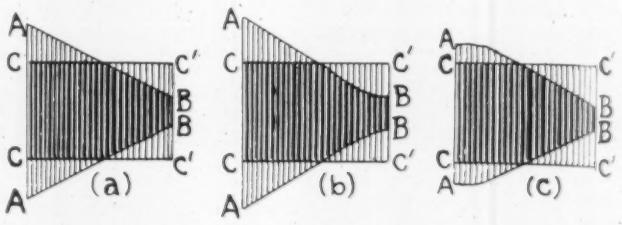


Fig. 5

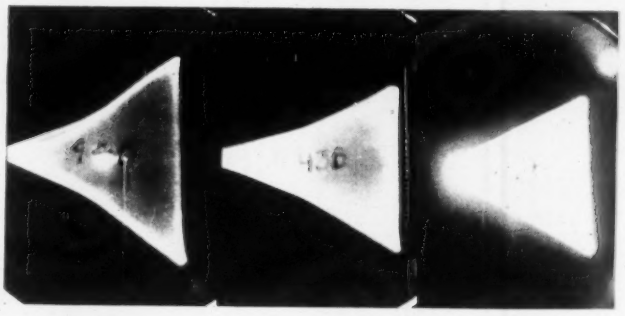


Fig. 6

Fig. 6 is an oscillogram with more linear characteristics. These Fig. 6-photographs were exposures of approximately 2 seconds with a 5″ DuMont tube, using the camera shown in Fig. 8 of the July 1936 article. The numbers were written on the face of the tube with a pen.

MODULATION OSCILLOGRAM ANALYSIS

In the trapezoid type of oscillogram, any departure of the contour of the sloping sides from a straight line should be investigated. A few representative examples have been sketched in Fig. 7 for analysis, though the following interpretation of the appearance cannot be taken as an accurate guide to all transmitter troubles since different causes may produce identical appearances on the screen.

Fig. 7A represents a partially modulated wave when a pure tone has been applied. This diagram represents the ideal case. In contrast the diagram (H) has been modulated by means of a speaking voice. Here the horizontal length of the figure varies continually, occupying the central portion of the screen most of the time, but at times extending to the right and left when impulses

syllables are spoken. The figure is therefore more intensely illuminated near the center. Modulation studies can be made with any type of input, therefore, although the steady tone is preferable.

If the modulating wave is distorted, certain brighter bands may appear on the diagram, such as (B) and (C); which might indicate the conditions when even and odd harmonics are introduced respectively. In (D) and (E) the modulated envelope is non linear, due to wrong biasing of the amplifier stage or to insufficient r.f. amplifier excitation. In (E) the negative peaks are also distorted.

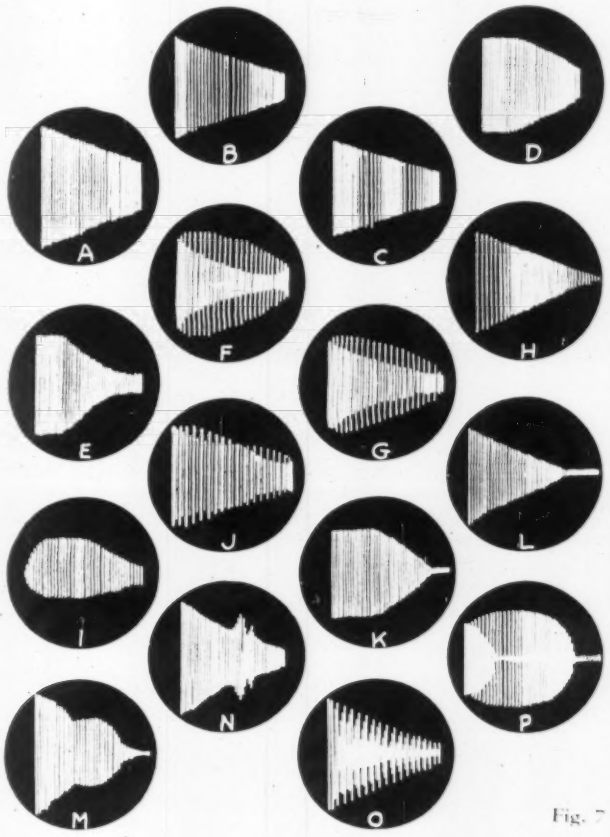


Fig. 7

such as might occur when a tube is used with insufficient anode potential.

(F) represents the phase shift condition previously referred to. In some cases when phase correction is applied so as to bring the narrowest part of the figure to the end of the diagram, some of the elliptical effect still remains, as in (G). This may be due to non-linearity of modulation and the effect is to be distinguished from non linearity of the r.f. amplifier, which produced an effect shown in (D) and (E). Overloading in the modulation choke or transformer might also account for (G). A similar condition brings out the effect of a double ellipse as in (J), also shown in Figs. 6A and 6B. The appearance (M) is sometimes caused by poor neutralization in amplifier stages although several other causes for this condition are possible as well.

In (K) the carrier has been reduced without changing the gain in the modulator stages so that the carrier is greatly over-modulated. Detunning the final amplifier tank circuit, or improper matching in the antenna coupling circuits, may account for such effects. In (L) another case of over-modulation is shown. The degree of overmodulation can be estimated by the fictitious value obtained when the sides of the diagram are extended giving a negative value to the minor dimension, B, used in the modulation formula. The sides are extended until they are in line with the tip of the figure as shown in the sketch at bottom of Fig. 5. This negative value for B is substituting this negative value for B in the same formula, which will give an apparent value of modulation percentage greater than unity.

In diagram (I) poor regulation of the power supply is indicated, so that the power level may drop as the modulation increases. This causes a rather disagreeable type of distortion. The effect of poor power supply regulation generally shows up in the doubler or buffer stages. When the final stage is a tetrode, modulation must be applied to both the plate and the screen circuits.

Fig. 8

for best results. If the plate alone is modulated the diagram (E) might be found, but in some cases it may be found that dynatron oscillations occur when the plate potential is modulated down to a value below the screen voltage. This gives a diagram somewhat as (N).

The oscillogram of a controlled carrier system (O) is rather hard to analyze as long as the carrier level is changed with modulation. Diagram (P) represents the output of a typical short-wave diathermy outfit, which delivers power only during every other half cycle. If the oscillator is not correctly balanced and properly loaded, however, this oscillogram might appear as Fig. 8 which was taken on one such outfit. The type of diagram shown in this figure indicates several strong harmonics in the r.f. output.

In the diagrams illustrated in Fig. 7 the distortion may not always be caused by the effect described, but the explanation may serve for preliminary studies. When some abnormal effect is indicated, the procedure is to make separate oscillographic studies of the several circuits feeding the final modulated stage. The effect of bias changes, or of various screen voltages, is readily apparent, either as a change in carrier output or in operating characteristics. The effect of power supply regulation can be studied by applying the potential from the master oscillator circuit to one pair of plates and the potential from the buffer stages to the other pair. Any non-linear condition existing is readily noted.

PARASITIC OSCILLATIONS

In many oscillator circuits, and in some amplifier circuits, parasitic oscillations are present which are not evident from instrument indications, but nevertheless cause lowered efficiency. The circuit Fig. 2d permits

(Continued on page 76)

INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

DECEMBER PROBLEM (No. 14)
TIRE TRACTION EFFICIENCY

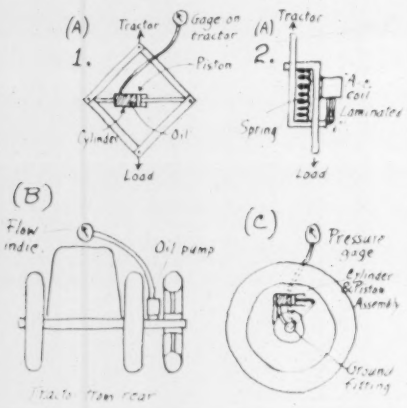
"Our Research Department plans a series of tests involving draw-bar pull of farm tractors, together with percentage slip of the tractor drive wheels at various values of draw-bar pull from zero to the maximum ability of the tractor. We desire to measure: (a) the slip of the wheel of the tractor (b) the draw-bar pull of the tractor (c) the rolling resistance of the tractor."

$5 PRIZE SOLUTION
By CLARENCE ANDERSON
FARGO, N. DAK.

Several methods are given to determine the different facts required; namely, (a) Draw-bar pull; (b) Slippage; (c) Rolling resistance.

(A) 1. One method of measuring pull would be to use a dynamometer of a parallelogram design with a hydraulic piston using oil as the medium of transmitting the pressure to a pressure gage calibrated in 1000 lbs. pull.

2. Another is to use a draw-bar of a spring-loaded sliding type to which is attached an a-c. current reactor coil so designed to change the current flowing in the coil by means of a moving iron



core. The current supplied by a portable a-c. plant of miniature type or possibly an a-c. generator on the tractor with voltage regulated. The variations in draw bar pull would be calibrated on an a-c. ammeter.

(B) A method of measuring slippage would be to install another driver and tire on an extension shaft from one of the drive shafts; this fifth wheel to be mounted on bearings to turn free—overall diameter same as driver. The slippage would show up as the difference in percentage of movement between this wheel and the wheel in question. The percentage could be indicated by a device on the differential principle and have each wheel drive an oil pressure pump, and at zero degrees slippage the pressure would balance as shown by a flow indicator on tractor and any slippage by the amount of movement of oil in either direction through the flow indicator.

(C) Again the use of the hydraulic force-measuring cylinder—one on each driver or possibly one on the drive shaft if the construction permits. The cylinder assembly is fastened to either the shaft or driver and the piston assembly to the remaining one. A ground fitting would have to be used to transmit the pressure on the oil in cylinder to gages calibrated in pounds torque. If used on drive shaft only one unit need be installed.

$5 PRIZE SOLUTION
By L. R. KETTENRING
SEATTLE, WASH'N

It is possible to secure an accurate chart record of draw-bar pull on a tractor by installing a calibrated tension spring in the draw-bar link with direct mechanical connection to a pen on a position recorder so as to record a range from zero to maximum spring extension.

The rate of tire slip can be recorded through an arrangement wherein a differential gear assembly provides a means of relating the speed of the tractor wheel and the time element. One side of

the differential is directly connected to the wheel in a manner similar to a speedometer connection. The other side of the differential is operated from a variable time device as hereafter described. The spider is connected through a slip clutch to a second pen on the position recorder so as to record the desired range of slip.

The variable time device used for driving the one side of the differential is of a frequently-used type wherein the applied speed varies uniformly in relation to the displacement of the spider. This is a strictly mechanical arrangement using a constant-speed motor driving a friction disk on which an adjustable friction wheel turns at speeds according to its contact location on the disk. The friction wheel adjustment is cared for by a worm operated by the drive from the spider of the differential.

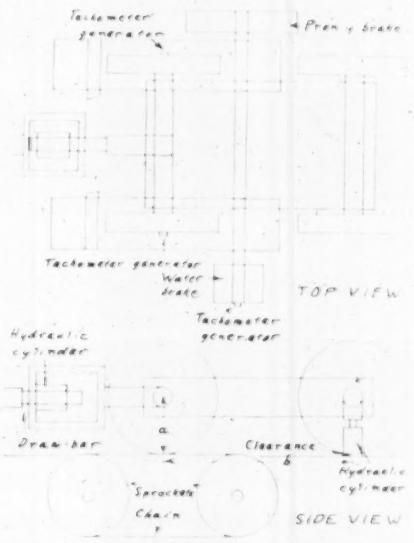
$5 PRIZE SOLUTION
By E. M. FRY, Jr.
ROSELLE PARK, N. J.

APPARATUS:—

Hydraulic cylinders; designed so that the pressure developed in them can be readily connected to a recorder, by keeping the head of the piston large in the case of the draw-bar and the head small in the case of the cylinder under the front axle.

Tachometer generators; the outputs of the generators are fed to recorders. One generator is connected to each rear wheel, and one to the shaft which is fastened to the driven sprocket.

Water brake; the power which this dynamometer dissipates does not have to be measured. It is just a unit to take care of speeds above stalling conditions.



Prony brake; the power dissipated here does not have to be measured either. It is used to bring the tractor to a stalling condition.

Sprockets and chain drive; shown here for simplicity of calculations. Commercial brake testers allow rear wheels to run on two rolls to obtain maximum traction.

PROCEDURE:—

The pressure developed in the hydraulic cylinder under the front axle is measured on the recorder when the engine is not running. This gives the tare which must be subtracted from readings which are taken when the equipment is in operation. As shown in the sketch the front end of the tractor is supported by the cylinder so that a small clearance is obtained between the front wheels and the floor.

The two pressure recorders and the three tachometer recorder charts are now marked so that corresponding time co-

Problem No. 16 — Subject Index 2.05

CONTINUOUSLY MEASURING SMALL FLOW OF LIQUID

Research Director seeks method of indicating flow rate of methanol: 0 to 5.0 lbs. hr.; has found drop-count methods inaccurate.

Five dollars will be paid for every solution (or critical discussion clearly pointing the way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Mail before March 15. Solutions and discussions accepted will appear in April 1938 issue.

dinates can be determined. The engine is started and the water brake is used to bring the tractor speed down to the point where the brake can no longer dissipate energy readily. Incidentally, it would be advisable to install a gear box between the rolls and the water brake in order to keep the operating speed of the brake as high as feasible.

Power dissipation curves on water brakes show that their usefulness drops off considerably with speed. Then the prony brake comes into use to bring the engine to the stalled condition.

DISCUSSION:

To obtain the continuous and instantaneous values of slip of the rear wheels let us consider the data taken by the tachometers. The tachometer on the shaft extending through the sprocket will give the ground speed of the tractor. The tachometers on the rear wheels give the instantaneous speed of the wheels at all times. After the run is completed a comparison of the charts will show slip directly.

Total tire thrust can be obtained from the forces indicated by the pressure recorders. One can easily rotate the force pushing down on the front axle into a force which is in line with the draw-bar pull. If X is the force which can be added directly to the draw-bar pull and Y is the force computed from the pressure obtained in the cylinder under the front axle, then (referring to drawing):

$$X = Yb/a$$

Therefore, adding values of draw-bar pull computed from the pressure recorder connected to the draw-bar and rotated values of front axle forces, will give instantaneous and continuous values of total tire thrust.

CORRELATION WITH ROAD WORK:

The tractor would have to be taken on the road to get comparison data between the slippage which occurs on the rolls and on the road. However I think that the small effect of rolling resistance under stalled conditions could be disregarded and data obtained from which could be calculated a suitable coefficient.

DISADVANTAGES OF ROAD TESTING:

The tests could be conducted on the road by suspending the front end of the tractor from a crane on a towing truck. The cylinder which was under the front axle would now be placed in a yoke, similar to the one in the draw-bar, and used to measure the same force as before. A tachometer would have to be connected to the wheel of the towing truck. Or a fifth wheel unit could be attached to the side of the tractor. All recorders would have to be spring wound which is poor. If any rapid acceleration took place the mass of the tractor would have to be taken into consideration. Also I feel that it would take a skilled towing truck driver to maintain the point of suspension above the front axle and some method to record the angle of suspension would have to be devised.

85 PRIZE DISCUSSION

By ELMO E. HANSON
MINNEAPOLIS, MINN.

The problem of recording the draw-bar pull of the tractor could be solved by the method used by Professors Stinson and Roberts of Ohio State University in their measurements of the coefficient of friction between tires and road surfaces.[1] Their method of recording the draw-bar pull between a trailer and a tow-car is to use a hydraulic dynamometer consisting of a piston and cylinder filled with a glycerine-alcohol mixture and a conventional engine indicator unit for recording the fluid pressures on a moving strip of paper.

The tire slippage could be measured by recording on this same chart the motion of the tractor drive wheels and of a freely turning reference wheel (either an auxiliary wheel on the tractor or a front tractor wheel). The recording could be done in the manner of Stinson and Roberts: by providing the reference wheel and each traction wheel with a number of equally spaced electrical contacts to close the circuits of electromagnetically operated recording pens, three series of marks would be made on the recording paper corresponding to the motion of the three wheels. When the set-up has been calibrated for zero slippage, this record gives then the distance travelled by the periphery of each of the tractor wheels corresponding to the actual distance travelled by the periphery of the reference wheel (*i.e.* the distance traveled by the tractor). If l_t is the distance turned by a traction wheel while the reference wheel has turned a distance l_r, the percent slippage would be $(l_r - l_t)/l_r \times 100\%$. The objection might be raised that these values of slippage are not instantaneous; however, if these mean slippages are plotted against the mean time (obtained from the paper chart which could be driven at a constant known speed by a synchronous motor), the instantaneous slippage could be read from the slippage-time curve. To record instantaneous slippages would require the simultaneous recording of the speeds of the reference wheel and the traction wheels. This could perhaps be done by using electrical r.p.m. indicators with an oscillograph arrangement. However, this would seem to be impractical because of the vibrations in the tractor which would have to carry the recording apparatus.

The rolling resistance of the tractor is a function of only its velocity for a given tire and testing ground. In any case the rolling resistance would be small compared to the draw-bar pull, and the following method of measurement would be suitable. With zero draw bar load on the tractor, bring it up to its maximum speed and allow it to coast freely to a stop and at the same time use the recording apparatus to obtain a record of the distance traveled as a function of time. From the distance *vs.* time curve as obtained the deceleration of the tractor could be calculated as a function of the velocity. The deceleration and the velocity could be computed graphically, or if one finds the equation of the distance-time curve $d = f(t)$, the velocity at the time t would be $v = \frac{df(t)}{dt}$ and the deceleration would be $a = \frac{d^2f(t)}{dt^2}$. If the mass of the tractor and operator is M pounds and the deceleration is "a" feet/sec.^{2}, the rolling friction is $Ma/32.2$ pounds. If the tractor speed were calculated for the draw bar and slippage experiment, the corresponding rolling friction could be read off the rolling friction *vs.* velocity curve obtained by the above method.

If it were extremely important to obtain a record which would require less calculation, it might be possible to develop a method whereby the total torque applied to the tractor wheels would be recorded by an oscillograph actuated by piezoelectric potentials generated in say quartz crystals set properly in a divided drive shaft. Electrical r.p.m. indicators would also record on an oscillograph the simultaneous speeds of the drive wheels and reference wheel to indicate slippage. However, this would require extensive research in itself. The first method described is simple and would undoubtedly work.

[1] K. W. Stinson & C. P. Roberts, *Proceedings of the Thirteenth Annual Meeting of the Highway Research Board*, December 1933.

INSTRUMENTS' BOOK SHELF

Manual of Physical Measurements. (Sixth Edition). By ANTHONY ZELENY and HENRY A. ERIKSON. McGraw-Hill Book Co., New York. 1937. Cloth, 5½×8¾ inches, xxiv + 273 pages. Price $2.25.

The first 158 pages of this manual are devoted to laboratory exercises for use in a general course in college physics, while the last 96 pages treat experiments in more advanced electrical measurements. The experiments are carefully chosen to illustrate fundamental principles. The use of standard apparatus in nearly all of the experiments makes this manual adaptable to most college laboratories. The explanations and directions are made clear without repeating material which the student should find in his textbook.

The introduction contains one of the best treatments on the subject of experimental errors to be found in any elementary manual. The manual is to be highly recommended.

—EMERSON M. PUGH, *Associate Professor of Physics, Carnegie Institute of Technology, Pittsburgh, Pa.* (1)-B-

Strom-und Spannungswandler. By M. WALTER. R. Oldenbourg, Munchen, Germany. 1937. Cloth, 6½ × 9¾ inches, 159 pages. Price 8.80 RM.

In a condensed and clear way this book makes the reader familiar with the large and important field of the design and proper application of current and voltage transformers. The theory is held in an elementary form, based on the vector diagram. The characteristics required for these transformers both for measuring and relay purposes with different connections and under a large variety of loading conditions are thoroughly delt with and should be of great value to the central station and operating engineer. The application follows the German regulations and practices. The American reader will be impressed with the numerous illustrations showing different designs which have lately been developed in Germany and will undoubtedly agree with the author's statement that Germany is in a leading position in regard to original constructions.

—H. FAHNOY, *Consulting Development Engineer, Westinghouse Elec. & Mfg. Co., Sharon, Pa.* (4.21)-H-

Light - Principles and Experiments. By GEORGE S. MONK. McGraw-Hill Book Co., New York. 1937. Cloth, 6¼ × 9¼ inches, xii + 477 pages. Price $5.00.

This is an excellent book for the intermediate and advanced student of light. Sufficient but not too much space is devoted to geometrical optics and optical instruments. This is essential for the proper understanding of the problems of Physical Optics.

Those phenomena of Physical Optics which are concerned only with passage of light through space such as refraction, diffraction, interference, etc., are treated by the classical wave theory

while for those phenomena where an interchange of energy between radiation and matter is involved as, for example, the production of spectra, magneto-optics, etc., the elementary quantum theory is used. By so doing the student covers the various phenomena of light in the simplest manner and is prepared for the more advanced problems of physical optics.

The third part of the book covers a well chosen set of laboratory experiments which will greatly assist in understanding the subject matter of geometrical and physical optics as well as familiarize the student with optical instruments and methods.

No one subject is given an undue amount of space at the sacrifice of some other division. The book should find a wide use not only as a text-book but as a reference book as well.

H. C. Rentschler, *Director of Research, Ionic Division, Westinghouse Elec. & Mfg. Co., Bloomfield, N. J.*

(7)-B-

Fundamentals of Physical Optics—1st Edition. Francis A. Jenkins & Harvey E. White. McGraw-Hill Book Co., New York, 1937. Cloth, 6 × 9¼ inches, xiv + 453 pages. Price $5.00.

In writing a textbook of advanced college grade which limits itself severely to those part of physical optics which can be treated by wave methods, the authors have achieved an admirable degree of unity and freedom from the alternations between quantum and classical points of view which are usually so puzzling to learners in the field. No space at all is given to geometrical optics, and only a few qualitative references are made to the quantum theory where necessary.

Being thus left ample space for what are correctly entitled the fundamentals the book gives a complete and continuous development of the subject matter. The detail of explanation and the excellence of the illustrations should recommend themselves to readers who wish to obtain a good grasp of physical optics without laboratory or other formal instruction. Of the 274 illustrations, 34 are photographs of interference and diffraction patterns and spectra. The remainder are line drawings so good as to be almost self-explanatory, adding greatly to the ease with which the text material may be assimilated.

The first half of the book is devoted to wave motion, interference, diffraction, and velocity of propagation. A chapter on electromagnetic theory precedes the discussion of emission, absorption, polarization phenomena, and reflection, but comparatively little subsequent use is made of electromagnetic considerations. In all of the latter chapters the descriptive or experimental aspect of the material is stressed, and the theory is deferred to the end of the chapter. In many instances long derivations of theoretical relationships are replaced by mere statements of results. Although calculus methods are used throughout, a considerable amount of information is available to the reader whose mathematical equipment includes only algebra and analytical geometry. There is an average of about ten problems at the end of each of the 19 chapters.

J. S. Campbell, *Institute of Optics, University of Rochester, Rochester, N. Y.*

(7)-B-

INSTRUMERRIMENT

Mrs. Pyrometer* Speaking

By Lois Leonard Engelhard

I'm just a gal who's heard a lot 'bout instruments for years:
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And portables, and opticals, and special leadwires too.
I've heard that your high temps require the finest plat'num 'couples.
And two protection tubes cut down contamination troubles.
I've learned a bit of many facts on matters such as these
But what I took and really know is teaching A B C's.

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When you talk about your gadgets
You're worse gabbers than your wives.

*Several years ago, one of our friends dubbed my husband and me "Mr. and Mrs. Pyrometer" and our children "the little Thermocouples." L. L. E. (Mrs. Wm. E. Engelhard)

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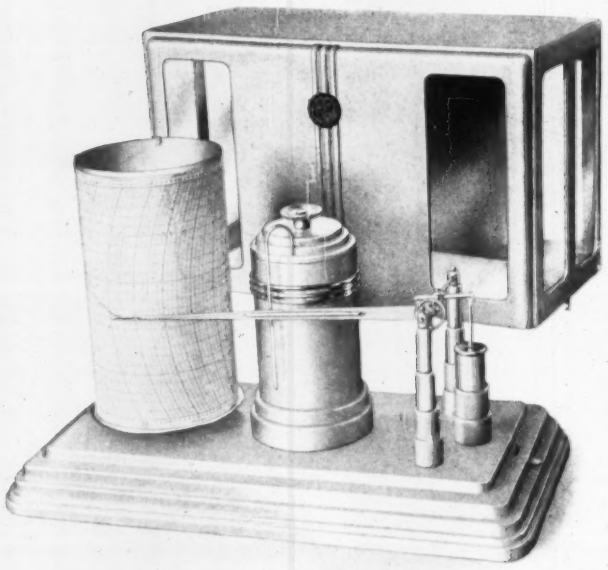

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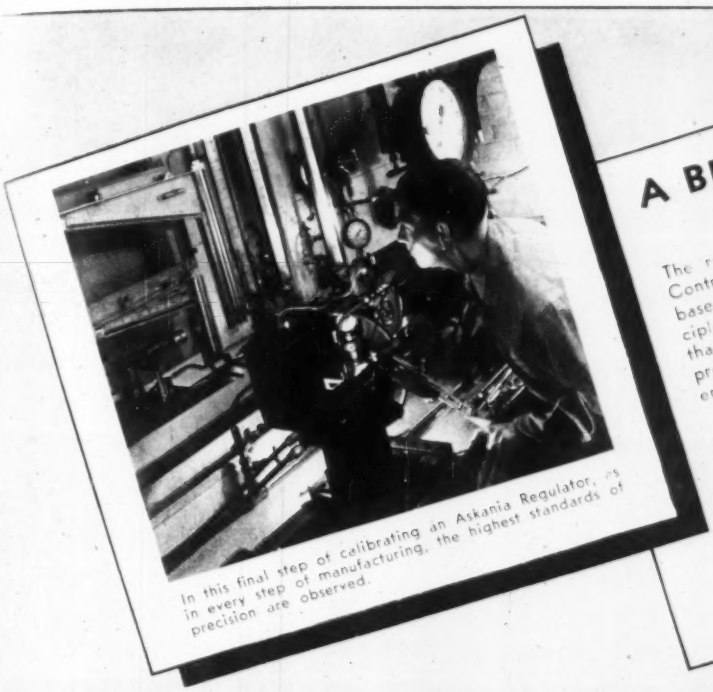

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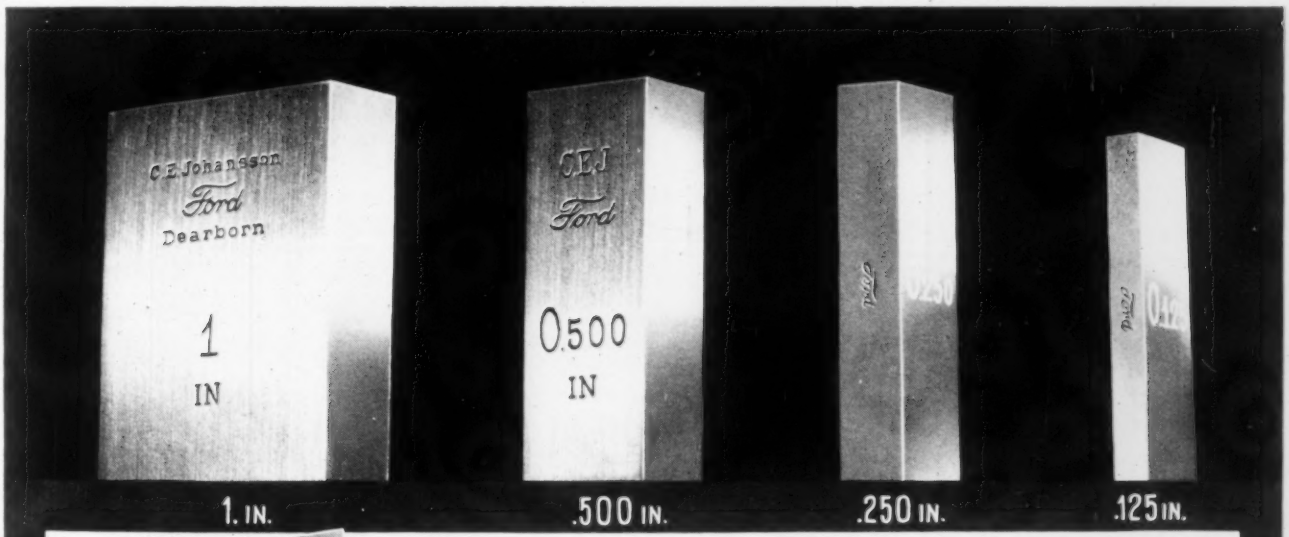

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